Process Monitoring of Organics During Dynamic Underground Stripping

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Abstract

Rigorous analytical monitoring was required to evaluate the effectiveness of Dynamic Underground Stripping as a remediation technology. Chemical concentrations measured throughout the treatment system were used to calculate contaminant mass removed from the vapor and liquid streams, to monitor contaminant concentrations for discharge compliance, and to characterize the recovered contaminant.

Daily vapor and liquid samples were taken from six ports throughout the treatment system and analyzed by gas chromatography for total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, and xylenes (BTEX). By using selective detectors on different instruments we distinguished between concentration variability caused by the process or by the analytical method.

Data in this section summarizes daily concentrations of total petroleum hydrocarbons (TPH) and BTEX concentrations collected from vapor and aqueous sampling ports during and after steam injection. Samples were analyzed overnight so that results were available within 24 hours to implement changes in extraction rates and treatment facility operations as needed. Concentrations of total hydrocarbons in the vapor phase ranged between 4,000 and 76,000 ppmv and constituted 80% of the extracted gasoline. Less than 0.1% of the total gasoline was detected in the aqueous phase, however, and TPH ranged between 12,000 and 40,000 ppb. The remaining 20% was collected as vapor condensate.

Constituents of the extracted gasoline collected at weekly intervals were identified by GC/MS to characterize the recovered contamination. The alkanes were preferentially recovered in the early phases of steam injection and were gradually replaced by the alkyl substituted aromatics.

Glossary

Accuracy—Combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.

Bias—Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

Calibration standard—A solution prepared from the primary dilution standard solution and stock standard solutions of the internal standards and surrogate analytes. The calibration standard solutions are used to calibrate the instrument response with respect to analyte concentration.

Calibration check standard—Standard used to determine the state of calibration of an instrument between periodic recalibrations.

Duplicate—Usually the smallest number of replicates (two), but specifically herein refers to duplicate samples, i.e., two samples taken at the same time from one location.

Field duplicates—Two separate samples collected at the same time and place under identical circumstances and treated exactly the same throughout field and laboratory procedures. Analyses of field duplicates give a measure of the precision associated with sample collection, preservation and storage, as well as with laboratory procedures.

Field reagent blank—Reagent water placed in a sample container in the laboratory and treated as a sample in all respects, including exposure to sampling site conditions, storage, preservation and all analytical procedures. The purpose of the field reagent blank is to determine if method analytes or other interferences are present in the field environment.

Internal standard—A pure compound added to a solution in known amounts and used to measure the relative responses of other method compounds and surrogates that are components of the same solution.

Laboratory duplicates—Two sample aliquots taken in the analytical laboratory and analyzed separately with identical procedures. Analysis of laboratory duplicates give a measure of the precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

Laboratory fortified blank—An aliquot of reagent water to which known quantities of the method analytes are added in the laboratory. The laboratory fortified blank is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements at the required method detection limit.

Laboratory fortified sample matrix—An aliquot of an environmental sample to which known quantities of the method analytes are added in the laboratory. The laboratory fortified sample matrix is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the laboratory fortified sample matrix corrected for background concentrations.

Laboratory performance check solution—A solution of method analytes, surrogate compounds, and internal standards used to evaluate the performance of the instrument system with respect to a defined set of method criteria.

Laboratory reagent blank—An aliquot of reagent water that is treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with other samples. The laboratory reagent blank is used to determine if method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus.

Limit of detection—The lowest concentration level that can be determined to be statistically different from a blank.

Limit of quantitation—The level above which quantitative results may be obtained with a specified degree of confidence. Confidence in the apparent analyte concentration increases as the analyte signal increases above the limit of detection.

Method detection limit—The lowest concentration of analyte that a method can detect reliably in either a sample or blank.

Precision—Measure of the degree of agreement among replicate analyses of a sample, usually expressed as the standard deviation.

Primary dilution standard solution—A solution of several analytes prepared in the laboratory from stock standard solutions and diluted as needed to prepare calibration solutions and other needed analyte solutions.

Quality assessment—Procedure for determining the quality of laboratory measurements by use of data from internal and external quality control measures.

Quality assurance—A definitive plan for laboratory operation that specifies the measures used to produce data of known precision and bias.

Quality control sample—A sample matrix containing method analytes or a solution of method analytes in a water miscible solvent which is used to fortify reagent water or environmental samples. The quality control sample is obtained from a source external to the laboratory, and is used to check laboratory performance with externally prepared test materials.

Stock standard solution—A concentrated solution containing a single certified standard that is a method analyte, or a concentrated solution of a single analyte prepared in the laboratory with an assayed reference compound. Stock standard solutions are used to prepare primary dilution standards.

Surrogate standard—A pure standard, which is extremely unlikely to be found in any sample, and which is added to a sample aliquot in known amount just before processing so that the overall efficiency of a method can be determined.

List of Acronyms

COC	Chain of Custody
DUS	Dynamic Underground Stripping
ELCD	Electrolytical Conductivity Detector
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
ES & H	Environmental Safety and Health
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectroscopy
LDV	Low Dead Volume Injector
LLNL	Lawrence Livermore National Laboratory
LOD	Limit of Detection
mg/L	Milligrams per liter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
OVA	Organic Vapor Analyzer
OVM	Organic Vapor Meter
pH	Potential of Hydrogen
PID	Photoionization Detector
ppmv	Parts per million by volume
RSD%	Percent Relative Standard Deviation
SOP	Standard Operating Procedure
TH	Total Hydrocarbons
TPH	Total Petroleum Hydrocarbons
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

Introduction and Background

Evaluation of Dynamic Underground Stripping as an alternative remediation technology involved frequent sampling for monitoring contaminant levels during the process. Four major objectives were to:

1. Identify major contaminants and obtain concentrations for calculating daily contaminant mass removal from the vapor and liquid streams.
2. Characterize the contamination removed.
3. Measure destruction efficiencies of the treatment systems for discharge compliance.
4. Compare results with on-line monitoring instrumentation.

The focus of the analytical chemistry portion of Dynamic Underground Stripping was to make accurate measurements of contaminants extracted from the ground. Even though gasoline is a mixture of many components, standard analyses were selected for measuring total petroleum hydrocarbons (TPH) and the benzene, toluene, ethylbenzene, p-, m-, o- xylenes (BTEX) compounds so that consistent measurements could be made throughout the facility. The primary objective was to obtain accurate concentrations of contaminants from both vapor and liquid streams so that contaminant mass removed from the ground could be calculated.

Designing and maintaining a rigorous sampling and analysis schedule was essential to successfully prove the efficacy of Dynamic Underground Stripping. By using selective detectors on different instruments, we could distinguish between concentration variability caused by the process or by the analytical method. Lower variability was observed in the aqueous measurements especially once the water treatment system performance was improved. The vapor stream concentrations, on the other hand, showed higher variability and had to be sampled at closer intervals.

By diversifying the analyses (Total BTEX and TPH), the resulting mirror image plots of contamination recovery from both streams were easier to interpret and were essential for understanding the DUS process and treatment facility performance.

Methods

This section describes the aqueous and organic sampling procedures used during the DUS Project conducted at TFF.

TFF, as previously described, is a gasoline contaminated site and has two treatment streams (aqueous and vapor) and one organic recovery stream (the recovered product from the two streams). The aqueous and vapor treatment streams can be monitored and sampled as they travel through the facility.

Sampling of Water and Vapor Treatment Systems

Sampling Ports. Figures 1 and 2 present simplified schematics of TFF showing sampling ports for the water treatment system and vapor treatment system, respectively. The following list describes each sampling port designation:

Aqueous Ports

TFF-SEPI	Oil/water separator (OWS) influent, located after the ambient air heat exchanger
TFF-UVI	UV/oxidation system influent
TFF-UV05	UV/oxidation system effluent
TFF-E006-AQ	Facility effluent to sanitary sewer, located after the air stripping tanks
TFF-MEGA-AQ	Aqueous phase obtained from vapor stream OWS (aqueous condensate from flat plate heat exchanger)

Gasoline Port

TFF-MEGA-HC	Condensed gasoline obtained from vapor stream OWS ("organic" condensate from flat plate heat exchanger)

Vapor Ports

ICE-IN	Internal combustion engine influent, located after the flat plate heat exchanger
ICE-OUT	ICE effluent
TFF-CFI	GAC filter influent (air stripping tank off-gas vapor effluent; aqueous stream)
TFF-CFO	GAC filter effluent (vapor).

Table 1 summarizes the DUS project sampling schedule.
Tables 2 and 3 summarize the number of samples collected and the number of these samples analyzed for each sampling port during the first steam and second steam passes, respectively.

Table 1. Sampling schedule.

	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Sun.	Analyses
Sample locations (aqueous)								
TFF-SEPI	1/d	1/d	1/d	1/d	1/d	1/d	1/d	TPH,601/602-EDB
TFF-UVI	1/d	1/d	1/d	1/d	1/d	1/d	1/d	TPH,601/602-EDB
TFF-UVO5	1/d	1/d	1/d	1/d	1/d	1/d	1/d	TPH,601/602-EDB
TFF-E006-AQ	1/d	1/d	1/d	1/d	1/d	1/d	1/d	TPH,601/602-EDB
Sample locations (vapor)								
TFF-ICE-IN	2/d	2/d	2/d	2/d	2/d	2/d	2/d	FID[a]
	1/d[b]	1/d	1/d	1/d[b]	1/d	1/d	1/d	TPH

[a] Field measurement with OVA.

[b] Include BTEX.

Table 2. Sampling summary during the first steam pass.

	Number of samples	Number of analyses
Aqueous Sampling port		
TFF-GST	3	6
TFF-IOO6-AQ	1	2
TFF-SEPI	67	132
TFF-SEPE	3	6
TFF-UVI	67	134
TFF-UVO1	8	16
TFF-UVO2	9	18
TFF-UVO3	8	16
TFF-UV05	65	90
TFF-E006-AQ	58	84
Total	289	504
Vapor Sampling port		
TFF-I006-VPR	12	12
TFF-VESI	23	23
TFF-CFI	5	5
TFF-CFO	5	5
TFF-E006-VPR	13	13
Total	58	58

Table 3. Sampling summary during the second steam pass.

	Number of samples	Number of analyses
Aqueous Sampling port		
TFF-MEGA-AQ	34	68
TFF-SEPI	54	107
TFF-UVI	54	106
TFF-UV05	29	30
TFF-E006-AQ	38	38
TFF-TNK2-BOT	2	4
TFF-TNK3-BOT	12	24
TFF-SUDAN IV		51
Total	223	428
Vapor Sampling port		
TFF-I006-VPR	11	13
TFF-ICE-IN	160	206
TFF-ICE-OUT	12	12
TFF-CFI	7	7
TFF-CFO	5	7
Total	188	245

Two types of analyses were performed on the aqueous stream: purge & trap analysis of volatile organic compounds (VOCs) according to EPA's method 601/602 and total petroleum hydrocarbons (TPH) according to EPA's method 8015-M. The recovered organic material was analyzed for total hydrocarbons (TH) and composition changes over time were analyzed by mass spectrometry.

Aqueous Sampling for VOC Analysis

The following VOC sampling protocol was used to collect samples for analysis of a partial EPA 601/602 method including benzene, toluene, ethylbenzene, xylenes (para, meta, and ortho)(BTEX), 1,2-dichloroethane (1,2-DCA), chloroform, carbon tetrachloride, trichloroethylene (TCE), and ethylene dibromide (EDB), total petroleum hydrocarbons (TPH), and total hydrocarbon (TH) analysis.

Glass vials (VOAs) were purchased pre-cleaned to EPA standards. Two samples each were collected for EPA-601/602-EDB and two each for TPH (where applicable) from each port. Talc-free gloves were used during sampling. The vials were uncapped, and the inverted caps (sample side up) were placed in a clean area. Three sample line volumes were allowed to pass, unsampled, into a waste container prior to sampling. The edge of the sample line was then positioned at the top edge of the sample vial, and ground water was allowed to run down the side into the vial. Care was taken not to allow turbulent filling. The vials were filled just overflowing (showing a meniscus at the top of the vial) and were capped. Once filled, the vials were inverted and tapped gently to ensure that no head space was present. If air bubbles appeared, the vial was discarded and the port was resampled. Samples were also examined for presence of any free product. The vials were labeled, placed in zip-lock bags, and stored in a refrigerator. Sampling events were then documented in the TFF facility log book. The log book and page number became the Chain Of Custody (COC) document control number. The facility log book and the COC contained sample destination, analysis to be performed, designation, date, and time. Samples were shipped or delivered to the designated analytical laboratory and were kept at 4°C until analysis.

Organic sampling for TH & GC/MS analysis

GC/MS of recovered free product was performed to determine composition changes over time. Samples were collected from the megators with a Coliwasa and placed in VOA's as described in the previous section. Samples were then logged and handled in the same manner as the aqueous samples. All GC/MS analyses were done by Clayton Environmental Laboratory, CA.

For TH analysis, two 1-L amber glass jars (having Teflon inserts in the caps) were collected for each port sampled. The glass jars were pre-cleaned to EPA standards. Talc-free gloves were used during sampling. Both jars were opened, and their inverted caps set in a clean place. Three sample line volumes were allowed to pass, unsampled, into a waste container prior to sampling. The edge of the sample line was placed at the top edge of the glass sample jar. The water was allowed to run down the side into the jar. Care was taken during sampling so that turbulent filling did not occur. The jars were filled to just overflowing. The jars were not rinsed or excessively overflowed. Jars were filled so that a meniscus existed atop of the jar. The jars were capped once the caps were checked for cleanliness. The sample container was then examined for sampling anomalies. The jars were labeled with waterproof black ink, and placed in a plastic bag. Bagged samples were then placed into a cooler containing ice at 4°C. The sampling was then documented in the TFF facility log book. The log book and page number became the Chain Of Custody (COC) document control number. The facility log book and the COC contained sample destination, analysis to be performed, designation, date, and time. The COC ordered the appropriate off-site analyses.

Vapor sampling for VOC analysis

Specialized sampling equipment was used for drawing samples under vacuum from the vapor system into plastic "tedlar" bags. Sampling bags were inserted into a desiccator equipped with plumbing from the sample bag to the sample port. By drawing air from the desiccator, a vacuum around the sample bag was created producing a pressure gradient from the pipes into the bag. Sample bags were equilibrated with atmospheric temperature and pressure after removing them from the desiccator. This automatic adjustment to ambient conditions allowed laboratory chemists to directly report chemical concentrations from GC data. Samples were documented in the TFF facility log book as described in previous sections.

Laboratory Analyses

Total Petroleum Hydrocarbons

GC Apparatus. Analysis of total petroleum hydrocarbons (TPH) was performed using an autosampler (PTA-30W/S, Dynatech Precision Sampling Corp.) and purge and trap concentrator (Model 4460A, Trap #6: Tenax/Silica Gel/Charcoal, O.I. Corp.) coupled to a Hewlett Packard HP 5890 Series II gas chromatograph equipped with a flame ionization detector (FID). A fused-silica column (30 m × 0.53 mm i.d.) coated with 1.5 μm dimethylpolysiloxane (DB-1, CAT# 125-1032, J&W Scientific) was employed. The injector and detector temperatures were 200 and 220°C, respectively. The gas chromatograph oven was held at an initial temperature of 35°C for four minutes followed by temperature programming to 80°C at 8 deg/min, then to 220°C at 12 deg/min, and then to 240°C at 20 deg/min with a final hold at 240°C for two minutes. The purge, desorb and bake times were 11, 3 and 20 minutes, respectively. The desorb and bake temperatures were 180°C. An HP 3365 Series II Chemstation (DOS) was used for data collection, storage and integration.

Aqueous : samples were injected into the purge and trap sparge tube by the autosampler in 5-mL aliquots. For high concentration samples (i.e. TFF-MEGA-AQ, TFF-SEPI, and TFF-UVI) the autosampler was programmed to dilute the sample by a factor of ten (4.5 mL water added to 0.5 mL sample).

Vapor: samples were received in either 1-L tedlar bags or in 500-mL stainless steel spheres (SSS). Samples were injected directly into the gas chromatograph in 100-µL aliquots via a 100-µL gas-tight syringe equipped with a side-port needle (Hamilton). Two injections were made from each sample to ensure proper sample handling and representativeness.

Standards and Reagents. The gasoline employed to calibrate the method was free product (weathered gasoline) obtained from well GSW-15 in June of 1990 at Lawrence Livermore National Laboratory, Livermore, CA.

Aqueous: A working stock solution (10,000 mg/L) was prepared in 100 mL methanol (high purity, B & J Brand, Baxter Scientific Products) by addition of 1.36 mL weathered gasoline (density 0.735 g/mL). Standards were prepared from this working stock in the range of 250–25,000 ppm by addition of 1 to 100 µL of this working stock to clean water (filtered by a NANOpure, ultrapure water system, Model #D4741, Barnstead/Thermolyne; followed by a 30 minute sparge with helium) in 40 mL VOAs (I-Chem). Appropriate standard concentrations and dilution factors (usually 10-fold) were chosen that ranged between the concentrations of a given sample. Calibrations were run as required (generally monthly). Three different standard concentrations were checked prior to analysis of each set of samples, and the calibrations were deemed accurate if each of the three check standards was ±10% of its expected value.

Vapor: Standards were prepared in 250-mL glass vessels. The glass vessels were equipped with two stopcocks and a septum port. A new septa was placed on the vessel and the vessel was evacuated on the house vacuum for 30 minutes. The vessel was then removed from the house vacuum and 1 to 10 µL of gasoline was injected into it (resulting concentration: 832 to 8,320 ppmv). The vacuum was then relieved by rapid turning of the stopcocks, and allowed to equilibrate for 30 minutes before analysis. Three standards of differing concentrations were prepared and each one was injected twice (in 100-µL aliquots) to ensure proper sample handling.

TPH Window

TPH was defined as the concentration of all compounds that elute within the C6 to C12 window (hexane to dodecane).

Vapor: TPH was reported as mass per unit volume (mg/L or ng/μL) and parts per million by volume (ppmv). Reporting ppmv requires a molecular weight to convert mass/volume to ppmv (mol/mol). We report ppmv based on the molecular weight of hexane, 86 g/mol. The calculation is as follows:

$$\text{ppmv} = \frac{\text{mass of gas/molecular wt. of gas}}{\text{volume of air/molecular wt. of air}} \times 10^6$$

$$\text{ppmv} = \frac{\text{volume } (\mu\text{L}) \times \text{density } (\text{g/mL}) \times 1\text{ mL}/1000\ \mu\text{L} \times 24.4\text{ L/mol}}{0.25\text{ L} \times \text{MW } (\text{g/mol})} \times 10^6$$

$$\text{ppmv} = \frac{4 \times 24.4 \times \text{density } (\text{g/mL}) \times \text{volume } (\mu\text{L})}{1000 \times \text{MW } (\text{g/mol})} \times 10^6$$

In the early part of the second phase of the DUS (May through July 1993), some samples were observed to contain a large portion of low molecular weight compounds that elute prior to hexane and, therefore, outside of the TPH window. For these samples, we decided that the TPH value gave an inaccurate picture of the total amount of organic compounds in a given sample. For this reason, we defined a new value, which we termed "total hydrocarbons." The window for total hydrocarbons can be described as C_1 to C_{12} (methane to dodecane), as we included all compounds that elute prior to dodecane in this calculation.

Aqueous and Vapor VOC Analyses

GC Apparatus. Chromatography was performed using a Hewlett Packard 5890 series II gas chromatograph (GC) outfitted with a photoionization detector (PID) and an electrolytic conductivity detector (ELCD). A PTA-30 W/S autosampler (Dynatech Precision Sampling Corp.) was employed for aqueous sample analysis. A low dead volume (LDV) injector port with a transfer line attachment from an O.I. Analytical Corporation Model 4560 Liquid Sample Concentrator (#6 trap, tenax/silica gel/charcoal) was interfaced to the GC. The GC column was a J & W Scientific 30 m × 0.53 mm (inner diameter), fused silica DB624, with a film thickness of 3 micrometers. The GC injector port temperature was maintained at 190°C. The PID and ELCD temperatures were maintained at 220° and 900°C, respectively. The GC oven temperature profile had an initial temperature and duration of 50°C for 5 min. The oven then ramped 6°C per minute to a final temperature of 110°C. A postsample analysis bake-out was employed by ramping the oven at 20°C/min to 170°C for 3 min. After the GC analysis, the oven returned to 50°C and equilibrated for 1 min prior to analyzing the next sample.

The Liquid Sample Concentrator (purge and trap) was used for aqueous sample analysis and low VOC concentration vapor sample analysis. The purge, desorb, and bake times for liquid samples were 4, 3, and 20 min, respectively. The purge, desorb, and bake times for vapor samples were 8, 3, and 20 min, respectively. The purge, desorb, and bake temperatures for either liquid or vapor samples were 25°, 180°, and 190°C, respectively. HP Chemstation, an automated GC systems control and data acquisition programmable workstation, was used to gather, process, and archive the GC data.

BTEX and TCE were quantified by the PID while 1,2-DCA, Chloroform, Carbon Tetrachloride, and EDB were quantified with the ELCD.

Aqueous samples were received for 601/602-EDB analysis from TFF-SEPI, TFF-UVI, TFF-UV05, and TFF-E006-AQ sampling ports. The PTA-30 W/S autosampler was used to dilute (if necessary) and transfer the sample to the liquid sample concentrator. The dilutions performed by the autosampler were 1:5, 1:10, and 1:20. The final sample volume was 5 mL. Unpreserved aqueous samples were received in duplicate. One sample was analyzed immediately. The other sample was held for later analysis (confirmation purposes), or until its 2-week expiration date. Expired samples were returned to the sender for disposal.

Chlorobenzene was used as a surrogate to evaluate aqueous VOC recovery. Cis-1,3-dichloropropane was used as an internal standard to measure GC performance, and to generate the HP Chemstation internal standard sample concentration report.

Vapor samples were received in either 1-L tedlar bags or in 500-mL stainless steel spheres (SSS). Vapor samples were either introduced into the GC by direct injection into the LDV injector port (high VOC concentration samples), or injected into the purge and trap (low VOC concentration samples). The sample was deemed as a low VOC concentration sample, if the concentration was less than 50 ppmv. Duplicate injections were made on each sample. The injection volumes for low and high VOC concentration vapor samples were 20 mL and 10 microliters (µL), respectively. Injections were made using either a 25-µL or a 50-mL gas-tight syringe (Hamilton). The 25-µL syringe was equipped with a side port needle, and the 50-mL syringe was equipped with a Teflon stopcock (Supleco).

Low VOC concentration samples were introduced into the GC by injecting a 20-mL sample into the sparge tube (purge and trap) using a 50-mL Hamilton gas-tight syringe. The syringe was fitted with a stopcock and 18 gauge, 1.5-in. needle in order to remove the sample from the tedlar bag sample port. The syringe was flushed with the sample three times to ensure that a homogeneous vapor sample was entrapped within the syringe. Once a sample was drawn into the syringe, the stopcock at the syringe tip was placed in the off position. The needle was removed and the syringe was then attached to the purge and trap sparge tube. The syringe stopcock and the purge and trap sample port valve were then opened, and the sample was injected into the sparge tube. Once the sample was placed in the sparge tube, the purge and trap sample port valve was closed and the purge cycle started manually.

High VOC concentration samples were injected directly onto the GC with a 10-µL sample through the LDV injector port using a 25- or 50-µL Hamilton syringe equipped with a side port needle. The syringe needle was inserted into the tedlar bag sample port, and was flushed with sample at least three times to ensure that a homogeneous vapor sample was entrapped within the syringe. Ten microliters were drawn slowly into the syringe, and then the direct GC injection was made. The GC was started manually after sample injection.

Standards and Reagents

Neat compounds purchased from Chem Service, Inc. were used to prepare calibrations for aqueous and high VOC concentration vapor samples. Scotty's II certified vapor standards (1, 10, and 50 ppmv) were utilized to prepare calibrations for low VOC concentration vapor samples.

Aqueous: A 100-ppm (100 mg/L) working stock solution was prepared in 100 mL of high purity methanol (B & J Brand, Baxter Scientific Products). The working stock solution contained all compounds of interest. Working stock solutions were prepared in 120-mL clear glass serum bottles. The serum bottles were capped with Teflon-lined silicone septa, and aluminum crimp caps. The septa and caps were replaced after use. GC calibration standards were prepared in 40-mL VOAs by adding the appropriate volume of the neat reagent to 40 mL of ultrapure (0.22 micrometer filtered) water. The ultrapure water was acquired from a NANOpure ultrapure water system

(Barnstead/Thermolyne), and purged with helium for 30 min before use. PID GC calibration standards from 2.5 to 2,000 ppb were prepared from a 100-ppm working stock solution. ELCD GC calibration standards from 2.5 to 100 ppb were prepared from a 100-ppm working stock solution. Calibration standards were analyzed and entered into the Chemstation for each dilution factor used. The GC was calibrated every 2 weeks, and GC calibrations were examined daily using calibration checks. Recalibration of the GC would occur any time the calibration check varied 10% from the anticipated value.

Vapor: When the sample was received, the VOC concentration range was determined by checking previous results or by GC screening. The sample designation and analytical method were then entered into the HP Chemstation. Standards were prepared in a 500-mL stainless steel sphere or 1-L tedlar bags. Neat compounds purchased from Chem Service, Inc. for uncertified standards were prepared to the desired concentration. Standards were made in the laboratory by adding the proper amount of clean air to the tedlar bag and then injecting the appropriate quantity of neat VOC into the bag using a Hamilton syringe. The bag was then allowed to stabilize for 20 min prior to use. When the commercial standards were employed, a tedlar bag was filled with the vapor standard and analyzed by GC. Vapor standards were made daily and not reused beyond 24 h. Standards were analyzed weekly, and a response factor (RF) was used to calibrate the GC and quantify the vapor sample concentrations. The RF is the detector response (area counts) divided by the concentration and was checked weekly, Also, the GC was recalibrated if necessary.

Sample concentrations changed over time as the facility was extracting VOCs. Generally, samples collected from ICE-OUT and CFO contained low VOC concentrations, and samples collected from ICE-IN, I006-VPR, and individual well heads contained high VOC concentrations.

Use of Sudan IV as a Petroleum Indicator

Introduction

Sudan IV is a hydrophobic, synthetic organic compound. It is a non-ionic stain having a molecular weight of 380. Its formal histological use is as a lipid/lipine/fatty acid staining agent. Sudan IV will partition into the hydrophobic phase in biphasic hydrophobic/hydrophilic matrices. Sudan IV can be used to visually determine the presence of gasoline (free product) in aqueous matrices by staining gasoline red. We tried two different procedures for adding Sudan IV to the samples: dry reagent addition and saturated solution addition. Dry reagent addition was used when milliliter volumes of gasoline were present in the aqueous matrix. However, particulate matter (residual, insoluble Sudan IV) is present as a result of the dry reagent addition and interferes with visual observations of minute organic-phase quantities but dry reagent addition gives a rapid visual response (minutes). Sudan IV saturated solution addition was used when microliter quantities of gasoline might be present. The saturated stock solution is made in methanol and gives a slow visual response (hours).

Methods

Positive controls and negative controls were employed for both the dry and solvated reagent procedures. 40-mL VOAs were used for both procedures since the samples were received in these vials. Positive controls verified specific Sudan IV organic-phase partitioning while negative controls verified the nonspecific Sudan IV organic-phase partitioning. It was important to have 1.0 to 1.5 mL of head space when adding Sudan IV (dry or wet) to the VOA. In our case, the VOAs had been analyzed for VOC's so the required head space was present. 1.0 to 1.5 mL of the sample was removed if there was no headspace prior to the assay.

The positive control for the dry reagent addition method was prepared by injecting (using a 1-mL disposable plastic syringe) 0.5 mL of gasoline into a capped 40 mL VOA of water containing a stir bar and 0.5 mg of dry Sudan IV. The VOA contents were stirred for 1 minute, inverted, and placed in a rack for 5 minutes before recording the stain partitioning results. The negative control was prepared similarly, but without addition of the gasoline. Unknown samples were first visually examined for the presence of any organic phase and then treated like the controls. A stir bar and 0.5 mg of Sudan IV were added to the sample and the results were recorded after 5 minutes.

The Sudan IV solution addition method employs a saturated solution of Sudan IV in methanol. The positive control was prepared by injecting 2 to 10 microliters (µL) of gasoline into a capped 40 mL VOA of water containing a stir bar. Then 1.5 mL of the saturated Sudan IV solution was injected into the VOA. The contents were stirred for 1 minute, inverted, and placed in a rack for 24 hours before stain partitioning results were recorded. The negative control was prepared in a similar way, but without addition of the gasoline. Unknown samples were first visually inspected for the presence of an organic phase and then treated like the controls.

Gasoline Saturation Experiments

During the course of the first steam pass some concern arose over the high level of contaminant concentrations observed. If the saturation point of the gasoline in water had been reached, then it was possible that large volumes of gasoline were passing through the aqueous stream without being accounted for. The maximum concentration of total BTEX in the SEPI sampling port was reported on February 12, 1993 as 48,100 µg/L. The maximum concentration for TPH was 172,000 µg/L on March 13, 1993. If the water was indeed saturated with gasoline, then these values would represent only a fraction of the total mass of contaminants being removed from the site.

After the conclusion of the first steam pass the ultraviolet/peroxidation system was drained and opened for inspection. Inside the system, a small quantity (ca. 100 mL) of free product (TFF-UV-HC) was found. This finding would appear to support the idea that the gasoline had surpassed its saturation point in water. However, visual inspection of samples received showed no evidence of an organic phase. Also noted was that in none of the 23 samples taken from the MEGA-AQ sampling port and treated with Sudan IV during the second steam pass, was an organic phase detected. These samples had a maximum total BTEX concentration of 52,000 µg/L and a maximum TPH concentration of 154,000 µg/L (sample taken on May 30, 1993; elapsed time: 7.04 days).

Experiments were performed in the lab to determine the solubility of gasoline in water. Two different types of gasoline were employed and they gave two different results (see Table 4). The gasolines used were free product obtained from GSW-15 in June 1990 (the same gasoline used for calibrations in TPH analyses) and TFF-UV-HC obtained from the ultraviolet/peroxidation system in March 1993, as mentioned above. The general method was to add 1 mL of gasoline to a VOA containing ca. 38 mL of water (unless otherwise noted), and allow it to equilibrate for at least 24 hours. Each VOA was sampled periodically by transferring 0.4 mL of the aqueous phase to a 40-mL VOA containing 39.6 mL of water (two samples taken at each sampling period, one each for TPH and total BTEX). Note that the equilibration times given are not the actual time required to reach equilibrium (all appeared to reach equilibrium after only 24 hours), but are merely the time of the last sample taken.

The results obtained using free product from GSW-15 indicate that none of the samples taken during either steam pass had reached the saturation point of gasoline in water. However, the results obtained using the free product collected from the ultraviolet/peroxidation system would seem to indicate that it is possible that some of the samples had, in fact, been saturated with gasoline. The ultraviolet/peroxidation system causes the gasoline to undergo chemical changes, which affects its solubility.

Table 4. Saturation experiment results.

Water source	Gasoline source	Equilibration Time (hr)	Total BTEX (µg/L)	TPH (µg/L)
TFF [1]	GSW-15	48	105,000	222,000
TFF [1,2]	GSW-15	48	108,000	243,000
GSW-13	GSW-15	118	92,000	236,000
DI [3]	TFF-UV-HC	137	24,000	92,000
DI [3,4]	TFF-UV-HC	91	28,000	83,000
TFF-IOO6-AQ	TFF-UV-HC	25	28,000	68,000
GSW-13	TFF-UV-HC	118	18,000	75,000

Notes:

1. The exact source of the TFF water is unknown.
2. This sample was agitated during the equilibration period, and allowed to settle before sampling.
3. DI water is distilled water that has been filtered and purged with helium.
4. 50:50 mixture of gasoline and water.

Quality Assurance/Quality Control (QA/QC)

Water Analysis QA/QC

Surrogate Recoveries

Chlorobenzene was used as the surrogate spiking compound, and was added to every aqueous sample, including blanks. Project methods called for QC limits ranging between 50 and 150% of recovered surrogate in compliance with EPA recommendations. Recovery of chlorobenzene in Appendix E ranged between 60% and 134% which is well within the accepted QC limits (*Methods for the Determination of Organic Compounds in Drinking Water*, EPA-600/4-88/039, December 1988, page 46).

Field Spikes (Percent Recovery)

For analytical QA/QC, matrix spikes, and matrix spike duplicates were performed throughout the duration of the experiment. The spiking levels were three to five times the estimated amount for designated compounds present in the sample. The spiking compounds were added to the matrix spike and matrix spike duplicate aliquots of the sample before being placed on the purge-and-trap apparatus.

Calibration Method

The Internal Standard Method (ISTD) using the HP3365 Series II ChemStation Software calculates each peak separately and reports the absolute amount of material for each calibrated analyte. The results are independent of sample size, giving the most accurate analysis scheme for liquid samples. The PTA-30 W/S autosampler automatically delivers 100 ng of the internal standard, cis-1,3-Dichloropropene, to every sample. Since this internal standard is present in both unknown and calibrated samples, it serves as a reference or normalizing factor. Normalization of a compound (y) is done by

$$y\ (\mu g/L) = \text{Amount Ratio} \times \text{Actual Concentration of ISTD} \times \text{dilution factor},$$

where

$$\text{Amount Ratio} = \frac{A_y}{A_{\text{ISTD}}} \times \frac{R_y}{R_{\text{ISTD}}}$$

$(A)_y$	Area of compound y peak
$(A)_{ISTD}$	Area of internal standard peak
$(R)_y$	Ratio of y amount (µg/L) to unit area of peak y (detector response factor)
$(R)_{ISTD}$	Ratio of ISTD amount (100 ng) per unit area of the internal standard peak (detector response factor)

Limit of Detection

Limits of detection were set using the American Chemical Society recommendation that detection levels be set at three times the standard deviation of the noise level of the analytical measurement and that quantification levels be set at ten times the standard deviation. The range between three and ten times the standard deviation is considered uncertain for purposes of quantification. Table 5 presents detection limits for various VOCs by detector type ("Principles of Environmental Analysis," *Analytic Chemistry* 55, 2210–2218, December 1983, American Chemical Society).

Table 5. Detection limits (µg/L).

VOC	Photoionization detector (PID)	Electrolytic conductivity detector (ELCD)	Flame ionization detector (FID)
Benzene	0.2		
Toluene	0.2		
Ethyl benzene	0.2		
p,m-xylene	0.2		
o-xylene	0.2		
1,2-dichloroethane		0.2	
Trichloroethene	0.2	0.2	
Ethylene dibromide		0.2	
Chlorobenzene	0.2	0.2	
TPH			10

Criteria for Recalibration

Aqueous calibration checks were run daily using 25, 100, 2,500 µg/L of a list stock solution, which contained BTEX, 1,2-DCA, TCE, and EDB. If the calibration check standards varied by 10% of the anticipated value, the instrument was recalibrated. An NIST traceable external check sample was analyzed when a new calibration was performed. All methods used were calibrated by external calibration procedures using five to seven analyte concentrations.

Accuracy and Precision

Data quality criteria established in terms of precision and accuracy are presented in Table 6. Precision objectives are expressed in terms of relative percent difference (RPD). RPD is defined as the difference between two values, divided by their average. Precision was determined by using laboratory duplicates. The analyses of the duplicates met the analytical precision objectives of the project which were ± 20%.

Accuracy objectives were evaluated through the use of laboratory control samples and Matrix Spike/Matrix Spike duplicate analyses. Laboratory control samples are clean reference samples spiked with a known concentration of target analytes.

Table 6. Data quality criteria and objectives.

Parameter	Precision (RPD)	Accuracy (matrix % recovery)
TPH	3	80–120
Benzene	2	80–120
Toluene	2	80–120
Ethylbenzene	2	80–120
p-,m-Xylene	2	80–120
o-Xylene	2	80–120

Blank Analyses

Method blanks were analyzed for every three to four unknown samples showing no contaminants greater than the detection limit for the method being used.

Vapor Analysis QA/QC

Limit of Detection

The limit of detection for 10 μL of high VOC concentration samples was 1 ppmv for the compounds of interest. The limit of detection for 20 mL of the low VOC concentration samples were as follows: benzene, 0.015 ppmv; toluene, 0.100 ppmv; ethylbenzene, 0.005 ppmv; all xylene isomers, 0.007 ppmv each; 1,2-DCA, 0.010 ppmv; chloroform, 0.015 ppmv; carbon tetrachloride, 0.004 ppmv; TCE, 0.020 ppmv; and EDB, 0.003 ppmv.

Blank Spheres

Prior to use, 500-mL SSSs were cleaned, pressure checked, and analyzed for contaminants. Contaminated SSSs were flushed with clean air for 45 min to remove residual contamination. After the flushing, the valves were closed. GC analysis was then performed using an equal or larger sample than required by the method being performed. FID and PID/ELCD detectors were used to check for residual contamination.

Precision

The data quality criteria are established in terms of precision (see Table 7). Vapor samples were not spiked, therefore accuracy was not calculated. From duplicate analyses, the average difference, or average range, is calculated by summing all the differences (absolute values) and dividing by the number of observations: $R = \sum d_i/n$. This is converted to standard deviation(s) by dividing by 1.128 (*Standard Methods for the Examination of Water and Waste Water*, 18th Edition, 1992, 1030 C).

Table 7. Data Quality Criteria and Objectives

Parameter	*Precision* (*s*)
TPH	2.3
BTEX	2.7

Criteria for Recalibration

All analytical methods used were calibrated by external calibration procedures, using two to three standard concentrations, depending upon the method. A new calibration was performed at least once per quarter or as needed when the RSD was greater than 20%. Calibration checks were run daily using two concentrations of the external standard purchased from Scotty Specialty Gas, Inc. (10 and 50 mg/L BTEX).

Results

Baseline Pre-Steam

All data collected for the pre-steam baseline is located in Appendix A.

IOO6-AQ

IOO6-AQ is the designation for the combined extraction well influent to the aqueous treatment system. It is located before the heat exchanger (Fig. 1) and was, therefore, difficult to get representative samples due to high temperatures of the water once steam injection had begun. For this reason it was sampled minimally throughout the duration of the steam injection process. The SEPI (or SEPE, see below) sampling ports (located after the heat exchanger) were deemed to be better representatives of the contaminant concentrations in the ground water. The two times this port was sampled prior to steam injection it gave concentrations comparable to those measured from SEPE sampling port, differing in total BTEX concentration by less than 2% on each occasion (Appendix A).

SEPE

The SEPE sampling port is located after the oil/water separator and before the ultraviolet/peroxidation system (Fig. 1). This port is located upstream of UVI and the two are separated only by distance, as no treatment occurs between the two sampling ports. Differences of less than 1% were observed in total BTEX concentrations between SEPE and UVI in the two initial sampling dates. Therefore, for the remainder of the preliminary tests prior to steam injection, IOO6-AQ and SEPE were not sampled.

UVI, UVI1

These two sampling ports are found on the influent stream to the ultraviolet/peroxidation system (Fig. 1). Sampling of UVI was done to check the ultraviolet/peroxidation system performance and, since none of the upstream ports were sampled regularly, also to create a baseline database for contaminant concentrations in the ground water. Initial BTEX concentrations were 39,800 µg/L, but decreased steadily to 11,300 µg/L. In general, benzene was observed to be the major component comprising approximately 50% of the total BTEX concentration. Toluene and total xylenes were approximately 25 and 15–20%, respectively, while less than 5% of the total BTEX concentration was comprised of ethylbenzene. The benzene concentration remained fairly constant while the concentrations of each of the other components decreased by at least 80% (Fig. 3).

TCE concentrations were as high as 64 μg/L, but decreased to 7.8 μg/L on the final sampling date prior to steam injection. EDB had high initial concentrations (up to 168 μg/L), but decreased to less than 35 μg/L by the fourth sampling date and was not detected in the final five samples. 1,2-DCA showed the most variability with a maximum of 344 μg/L and a minimum of 18 μg/L on the final sampling date (Fig. 4).

UVI1 differs from UVI in that the hydrogen peroxide is added to the aqueous stream between these two sampling ports. UVI1 was only sampled prior to Underground Stripping while preliminary tests were being performed on the ultraviolet/peroxidation system, and on average had total BTEX concentrations that were lower by 17% than those found in UVI.

UVO1, UVO2, UVO3 and UV05

UVO1, UVO2, UVO3, and UVO5 are sampling ports located on the ultraviolet/peroxidation system. UVO*x* is taken after the water has made a pass by *x* number of ultraviolet lamps. The system is made for five total UV lamps, but was operated with only four in place, and so, the UVO4 sampling port was not sampled. The destruction efficiency of the unit was 5% in the initial test but was greater than 98% for each of the last twelve tests performed (see Fig. 5), and reached peak performance of 100% on four occasions (BTEX not detected in the UVO5 sample).

E006-AQ and E1

EOO6-AQ and E1 are two sampling ports located after the air stripping tanks (Fig. 1). E1 is downstream of EOO6-AQ and is the baker tank (a 5000 gallon tank for collecting treated water, see below) influent. In these preliminary tests the air stripping tanks were not in line, and as a result EOO6-AQ and E1 were essentially equivalent to UVO5.

BT-1961 and BT-1962

These are the designations for the two sampling ports located on the two baker tanks. The treated water was collected in the baker tanks and air sparged until the contaminant concentrations were brought under discharge limits. In these preliminary tests these two ports give the contaminant concentrations of the discharged water.

First Steam Pass Analytical Results

Groundwater

All data collected for the Aqueous samples during the first steam pass is located in Appendix C.

SEPI

SEPI was the designation for the aqueous sampling port of untreated ground water located after the heat exchanger (Fig. 1) represented water pumped directly from the wellhead and considered to have concentrations that were most representative of the groundwater. Initial TPH concentration in the water during the first steam pass was about 20 ppm and increased to as high as 172 ppm during 38 days of continuous pumping (Fig. 6). TPH concentrations were quite variable during this period ranging between 17 and 172 ppm. Three to 7-fold fluctuations in TPH concentrations were observed within a 24 h period.

Total BTEX concentrations showed the same variability with initial concentrations of 10 ppm increasing to 46 ppm during the same period (Fig. 6). Total BTEX ranged between 20 and 60% of TPH throughout the 39 days this port was sampled. The highest percentages were observed in the first 10 days of continuous operations. The highest percent of the BTEX components in the aqueous stream consisted of toluene averaging about 32% with maximum concentrations of 17 ppm (Fig. 7). Total xylenes were also high and averaged 42% of total BTEX with highest concentrations of 20 ppm. Benzene averaged 19% of total BTEX during the first steam pass even though percentages above 40% were measured in the first 2 days of continuous operations and then declined to about 20% for the following 37 days. Benzene concentrations ranged between 0.7 and 6 ppm during the 39 day period. Ethylbenzene constituted less than 10% of total BTEX and concentrations were measured between 0.3 and 3 ppm during the same period of time.

TCE concentration in the groundwater the first eight days was around 50 ppb (Fig. 8). Concentrations stabilized around 20 ppb for the next 31 days. 1,2-DCA, on the other hand, showed much larger fluctuations between 20 and 120 ppb. Concentrations of EDB were lower but similarly variable ranging between 11 and 47 ppb.

UVI and UV05

UVI was designated as the aqueous sampling port of water before exposure to the ultraviolet/peroxide oxidation system and downstream of SEPI (Fig. 1). Concentrations of TPH and total BTEX at UVI followed the same pattern as those at the SEPI port but were lower by less than 10% (Fig. 9). Percentages of the BTEX components also remained the same.

1,2-DCA, EDB, and TCE showed similar concentrations as the SEPI port and were also lower by less than 10%.

UV05 was the aqueous sampling port downstream of UVI after water was exposed to the ultraviolet/peroxide oxidation system (Fig. 1). Destruction efficiencies were calculated using BTEX concentrations measured from the UVI and UV05 ports. BTEX destruction efficiencies greater than 90% were achieved only in the first 5 days of continuous pumping (Fig. 10). After 5 days, destruction efficiencies fluctuated between 10 and 80%. Concentrations of total BTEX varied between 0.019 and 28 ppm depending on the performance of the unit.

1,2-DCA and EDB were not destroyed by UV peroxidation while TCE was reduced by 50%.

E006-AQ

The pumped ground water was discharged to sanitary sewer after air stripping and concentrations of total BTEX were monitored at the E006-AQ port (Fig. 1). Figure 11 shows total BTEX concentrations ranged between 0.3 and 71 ppb. Highest concentrations were measured during the first 12 days of operations and were typically less than 10 ppb thereafter. TCE, 1,2-DCA and EDB were never detected in the water from this sampling port.

Vapor

All data collected for the vapor samples for the pre-steam baseline is found in Appendix B, and the first steam pass samples are located in Appendix D.

VESI

VESI was the vapor sampling port located after the flat-plate heat exchanger and before the carbon adsorption system (Fig. 2). Laboratory analyses of Total BTEX concentration measured from this port was around 500 ppmv except for 11 days after continuous extraction when concentrations were measured as high as 2,000 ppmv (Fig. 12). Field measurements with the photovac showed the same trend (Fig. 13; Appendix G). Concentrations at 25 and 33 days reached 5,000 ppmv with continued field monitoring. BTEX components in the vapor stream were largely comprised of toluene (34%) and total xylenes (50%). Of the remainder, 11% was benzene and 6% was ethylbenzene.

During the first steam pass, vapor samples were also analyzed for 1,2-DCA, TCE, and EDB and were never detected.

IOO6-VPR

IOO6-VPR was the vapor sampling port located after the extractors and before the flat-plate heat exchanger (Fig. 2). Since the vapor was collected at 90°C and allowed to cool to ambient temperature, the samples contained a large volume of condensed water. The quality of the vapor concentration data from these samples is therefore uncertain but is found in Appendix B.

CFO and CFI

CFI and CFO were the GAC filter influent and effluent sampling ports. Few samples were taken at these ports and concentrations were very low.

Second Steam Pass

Groundwater

All data collected for the aqueous samples during the second steam pass is located in Appendix E.

SEPI

Initial TPH concentration in the groundwater before the second steam pass began was 76 ppm and dropped to approximately 16 ppm after 30 days of continuous pumping (Fig. 14). Concentrations of TPH remained relatively constant for the 75 days since the beginning of the second steam pass.

Total BTEX showed a similar trend with initial concentrations of 33 ppm dropping to 9 ppm during the same period. BTEX ranged between 40 and 60% of TPH throughout the 75 days this port was sampled. Both total xylenes and toluene constituted 37% of the BTEX components in the aqueous stream with maximum concentrations of 12 ppm in the first few days and 3 ppm after 30 days (Fig. 15). 16% of the total BTEX was measured as benzene. Concentrations were lower than the xylenes and toluene and ranged between 2 and 6 ppm during the 75 day period. Ethylbenzene was only 6% of total BTEX and concentrations were 2 ppm and dropped to less than 1 ppm during the same period.

1,2-DCA and EDB were not detected in the water during the second pass while TCE concentrations of pumped ground water remained steady at 20 ppb (Fig. 16).

UVI and UV05

Concentrations of TPH and total BTEX at UVI followed the same pattern as those at the SEPI port but were lower by 15% (Fig. 17). The percentages of the BTEX components also remained the same except for the percent of ethylbenzene was lowered to 3.

As observed in SEPI, 1,2-DCA and EDB concentrations remained non-detectable while TCE concentrations fluctuated between 16 and 50 ppb.

Destruction efficiencies of total BTEX by the UV peroxidation unit was greater than 98% after 30 days of operation (Fig. 18). Before 30 days, the efficiencies dropped to as low as 60%. Concentrations of total BTEX measured from UV05 varied between 0.013 and 17 ppm depending on the performance of the unit.

TCE in the water was reduced by 50% flowing from UVI to UV05.

E006-AQ

Concentrations of total BTEX and TCE were less than 10 ppb at E006-AQ before discharging the water. 1,2-DCA and EDB were never detected in the treated water (Fig. 19).

MEGA-AQ

MEGA-AQ was the sampling port after the oil–water separator of the aqueous portion of the vapor condensate (Fig. 1). TPH concentrations decreased almost linearly the first 16 days of continuous pumping from 142 ppm to 73 ppm (Fig. 20). Concentrations remained fairly constant at 80 ppm for the remaining 31 days. Total BTEX concentrations, on the other hand, remained constant around 40 ppm throughout 47 days. Percentages of the individual BTEX components were similar to those measured from SEPI and UVI ports except that benzene constituted only 9%. Benzene was a larger portion of total BTEX during the first nine days between 11 and 22% (Fig. 21).

Diversion of Aqueous Stream

TNK-BOT & TNK-TOP

During the second steam pass, three 600 gallon diversion tanks were plumbed into the aqueous steam between the oil/water separator and the UV peroxidation system. Water was periodically diverted into one of these tanks and held for 24 hours to check for separation into organic and aqueous phases. After 24 hours, a sample was taken from the bottom of the tank and analyzed (TFF-TNK-BOT). Concentrations of organics were observed to decrease by 50% during the 24 hour holding period. Due to the observed loss of organics during the diversion, two extra samples were taken at one and six hours holding time for the diversion conducted on June 15, 1993. Concentrations of organics were observed to decrease by 50% during the process of diverting the aqueous stream into the tanks while the concentrations remained relatively constant in the tank during the 24 hour holding period (see Table 8).

A second sample was skimmed from the top of each tank and treated with Sudan IV to check for the presence of an organic phase (TFF-TNK-TOP). The separation of an organic phase was never observed to occur in any of these samples. Similarly, separation into organic and aqueous phases was never observed in 14 tank diversions after holding for 24 hours.

Table 8. Diversion Tank Concentration vs. Holding Time.

Sampling Port	Holding Time (hr)	Total BTEX (µg/L)	Reduction (%)	TPH (µg/L)	Reduction (%)
SEPI-554H	•	11,800	•	26,900	•
TNK3-BOT-555H	1	•	•	12,600	53.2
TNK3-BOT-560H	6	5,980	49.3	12,100	55.0
TNK3-BOT-578H	24	5,930	49.7	10,800	59.9

A sample taken immediately after filling the tank (TNK3-BOT-555H) showed greater than 50% decrease in TPH concentration relative to a sample taken from SEPI (SEPI-554H) at the time of aqueous stream diversion. The TPH concentration decreased less than 7% during the following 24 hour holding time. The BTEX concentration showed a similar trend with the concentration decreasing by less than 1% during the final 18 hours of the holding time.

Sudan IV Staining of Aqueous Samples

A total of 65 aqueous samples (9 from SEPI; 26 from UVI; 23 from MEGA-AQ; 7 from TNKS) were stained with Sudan IV and only one from UVI was identified as slightly positive.

Vapor Analytical Results

All data collected for the vapor samples during the second steam pass is located in Appendix F.

ICE-IN

Initial concentration of total hydrocarbons measured from the ICE-IN port before the second steam pass was 90,000 ppmv (Fig. 22). After ten days of continuous extraction, concentrations decreased between 10,000 and 20,000 ppmv. TPH concentrations, on the other hand, were lower than total hydrocarbons by a factor of two during the first four days of extraction and then declined to approximately 15,000 ppmv until day 47 when 24 h operations were suspended. High TPH concentrations (46,000 ppmv) were again measured when 8 h operations were resumed 60 days from the beginning of the second steam pass. Concentrations continued to decline to 5,000 ppmv between 96 and 114 days post second steam. Similar results were obtained from field measurements with a Foxboro OVA (Fig. 23; Appendix H).

Total BTEX remained low (less than 5,000 ppmv) during the whole second steam pass and accounted for less than 25% of TPH (Fig. 24). The individual components are shown in Fig. 25.

ICE-OUT

Concentrations of total hydrocarbons was typically less than 250 ppmv except for on day 12 when concentrations were measured at about 1000 ppmv. Total BTEX from this port ranged between 0.9 and 14 ppmv. The highest concentration of 97 ppmv was measured on the 10th day.

I006-VPR

Total hydrocarbon concentrations measured from this port were similar to concentrations measured from ICE-IN for the first 18 days (APPENDIX D). Following heating the spheres to their ambient temperatures, the recovery of total hydrocarbons increased by 2.5-fold.

MEGA-HC

Significant changes in constituents of the organic vapor condensate were observed during the second steam pass (Table 9). Due to the complexity of gasoline chromatograms, only the ten largest identifiable peaks by GC/MS are shown. Presence of mostly alkanes and fewer aromatics were detected in the first 4 days of operation. During the 600 hours of operation that followed, the alkanes were gradually replaced by the alkyl substituted aromatics. m,p-xylenes constituted the highest percentage of the total between 11 and 15% but decreased to 4% after 29 days of continuous operation. Appearance of naphthalene, on the other hand, was observed after 25 days of extraction.

CFO & CFI

These samples were taken primarily for compliance monitoring purposes. Samples analyzed by gas chromatography for total hydrocarbons never exceeded 45 ppmv. However, these ports were monitored primarily with the OVA.

Table 9. Time comparison of total ion chromatograms (mass spectrophotometry) of samples taken from the MEGA-HC sampling port.

Retention time (min)	Tentatively identified compounds	5/25 (%)	5/27 (%)	6/3 (%)	6/15 (%)	6/17 (%)	6/21 (%)
1.97	2-Methyl pentane	3.4					
2.38	Methyl cyclopentane	3.1					
2.77	2-Methyl hexane	6.1	3.6				
2.88	3-Methyl hexane	4.1	2.4				
3.19	Heptane	3.6					
4.22	Toluene	12	11	3.9	3.2	2.8	
4.77	Octane		2.4				
5.87	Ethyl benzene		3.2	3.5	3.5	3.1	
6.08	m,p-Xylene	15	12	11	9.0	11	4.0
6.49	o-Xylene	4.2	4.9	4.9	5.0	4.6	2.7
7.55	Propylbenzene				2.8		
7.70	1-Ethyl-2-methyl benzene	4.8	6.6	4.5			5.2
7.82	1,3,5-Trimethyl benzene		2.6	7.0	8.8	9.7	
8.28	1,2,4-Trimethyl benzene		7.2	2.7	7.0	11	9.6
8.75	1,2,3-Trimethyl benzene	3.8		9.1	4.3	4.6	2.0
8.78	1-Ethyl-3-methyl benzene			4.5			
9.22	1-Methyl-3-propyl benzene			3.7	3.6	3.7	
9.80	1-Methyl-2-(1-methylethyl)benzene					3.0	3.0
10.77	1, 2, 3, 5-Tetramethylbenzene						2.3
10.83	1-Methyl-2-(2-propenyl)benzene						
11.28	C4 alkylbenzene				2.6		1.9
11.40	Naphthalene					2.8	3.0
13.00	2-Methylnaphthalene						2.7
13.24	1-Methylnaphthalene						2.7

Discussion

Vapor

The vapor stream accounted for 98% of the gasoline removal during DUS. Recovery from both streams were better understood after process modifications were made during the second steam pass. Many analytical uncertainties existed during the first steam pass because initially only BTEX compounds were analyzed and in addition, very limited sampling was done at the vapor treatment system. The ratio of total BTEX to TPH was estimated making daily mass removal of gasoline difficult to estimate. However, during the second steam pass, several process modifications were made as well as analytical adjustments to improve gasoline recovery estimates. The number of samples collected was increased three-fold and the type of analyses expanded to include TPH and TH, so that more information was gathered for each sample. During the second steam pass, TPH to TH ratios were constant except for the first four days of operation suggesting the preferential recovery of lighter (less than 6 carbon) compounds. GC/MS analysis of the extracted free product confirmed this.

Total BTEX and TPH concentrations versus time during the second steam pass, showed the same trends, suggesting that changes in the concentrations were due to the process and not to the analytical method used. In fact, consistent changes in hydrocarbon concentrations reflected the pattern of steam injection; highest concentrations were observed every time steam was shut off specifically on days 15, 29, and 38. These same patterns were verified with on-line monitoring instrumentation, as described above in the section entitled "Characterization of the Vapor Stream at the Lawrence Livermore Dynamic Stripping Site by Differential Ultraviolet Absorption Spectroscopy (DUVAS)." Diversifying the analyses and increasing the number of samples improved the data quality between the first and second steam passes.

Groundwater

Analytical results at the conclusion of the two steam passes indicated that the aqueous stream accounted for less than 2% of the removal of gasoline. Prolonged pumping and injection of steam during the first steam pass, caused a large quantity of particulate matter to accumulate in the UV/peroxide system that caused operational difficulties of the treatment facility and contributed to high variability in the data. During the second steam pass, no particulate matter accumulated in the UV/peroxide system and there was low concentration variability during the continuous pumping.

Aqueous samples were analyzed for TPH during the first steam pass unlike the vapor stream. TPH concentrations increased 5-fold during the first steam pass and declined exponentially to 25,000 ppb during the second pass. Percent of TPH that was BTEX was fairly constant during the second pass around 50 while during the first pass it varied between 20 and 60%. Causes of this variability were discussed above.

Destruction efficiency of the UV/peroxide unit was greatly improved in the second steam pass due to modifications made to the unit and monitoring concentrations of samples collected from the influent and effluent streams. As discussed earlier, during the first steam pass, a large amount of particulate matter was extracted from the subsurface which decreased the efficiency of the UV lamps. When the unit was opened for inspection at the end of the first pass, the lamps were coated with particulate and/or biological material. Small pools of gasoline were also present. This did not occur during the second steam pass.

The major analytical uncertainty after the first pass was whether or not free product was present in the water stream as an emulsion and therefore the concentrations were not measured accurately. The gasoline saturation experiments and the Sudan IV staining described in the results were done to verify contaminant concentration results from the purge and trap method. The results indicated that total BTEX concentrations in the aqueous stream were way below saturation and no emulsion was visible with the Sudan IV staining technique.

Prior to beginning the second steam pass, modifications were made to the treatment facility so that the vapor condensate was recovered from a separate stream and could be collected and measured as gasoline. This modification simplified gasoline recovery estimate calculations. Diversion of the aqueous stream into the tanks verified that an emulsion was not present and the contaminants measured by purge and trap analysis were dissolved in water.

Analytical adjustments for the aqueous stream during the second pass, was to diversify the analyses like the vapor stream. Both TPH and BTEX were measured by different instruments from different sampling ports. SEPI and UVI showed similar concentrations verifying that changes in concentrations during constant pumping were not due to errors in sampling and analysis but were directly related to the treatment process (e.g., steam pulses and extraction rates).

References

Methods for the Determination of Organic Compounds in Drinking Water, EPA-600/4-88/039, December 1988, p. 46.

"Principles of Environmental Analysis," *Analytic Chemistry* 55, 2210–2218, December 1983 (American Chemical Society).

List of Figures

Figure 23. Comparison of vapor total hydrocarbons concentration by GC and field OVA measured from the ICE-IN sampling port during the second steam pass.

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Simplified schematic of water treatment system

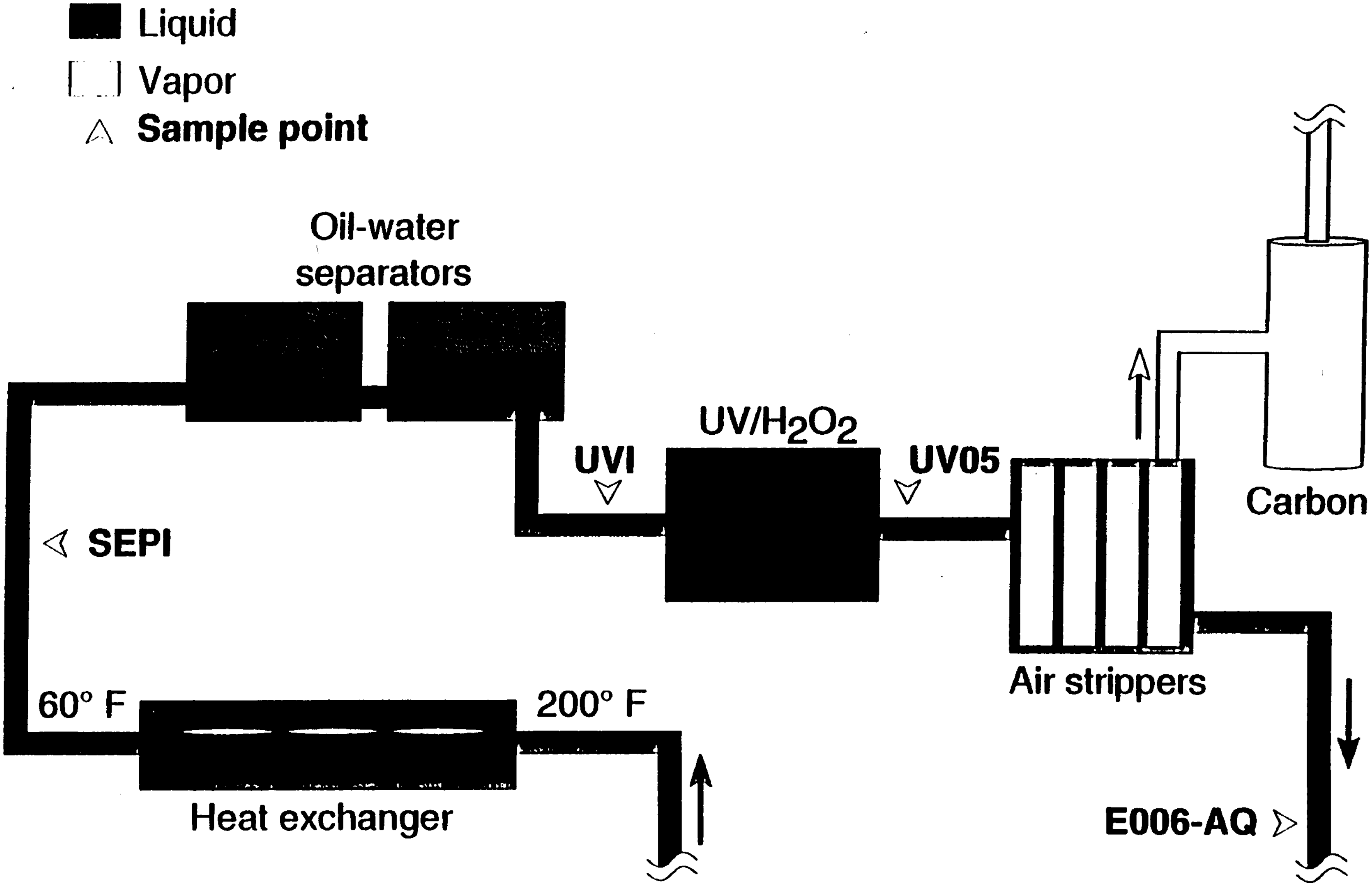
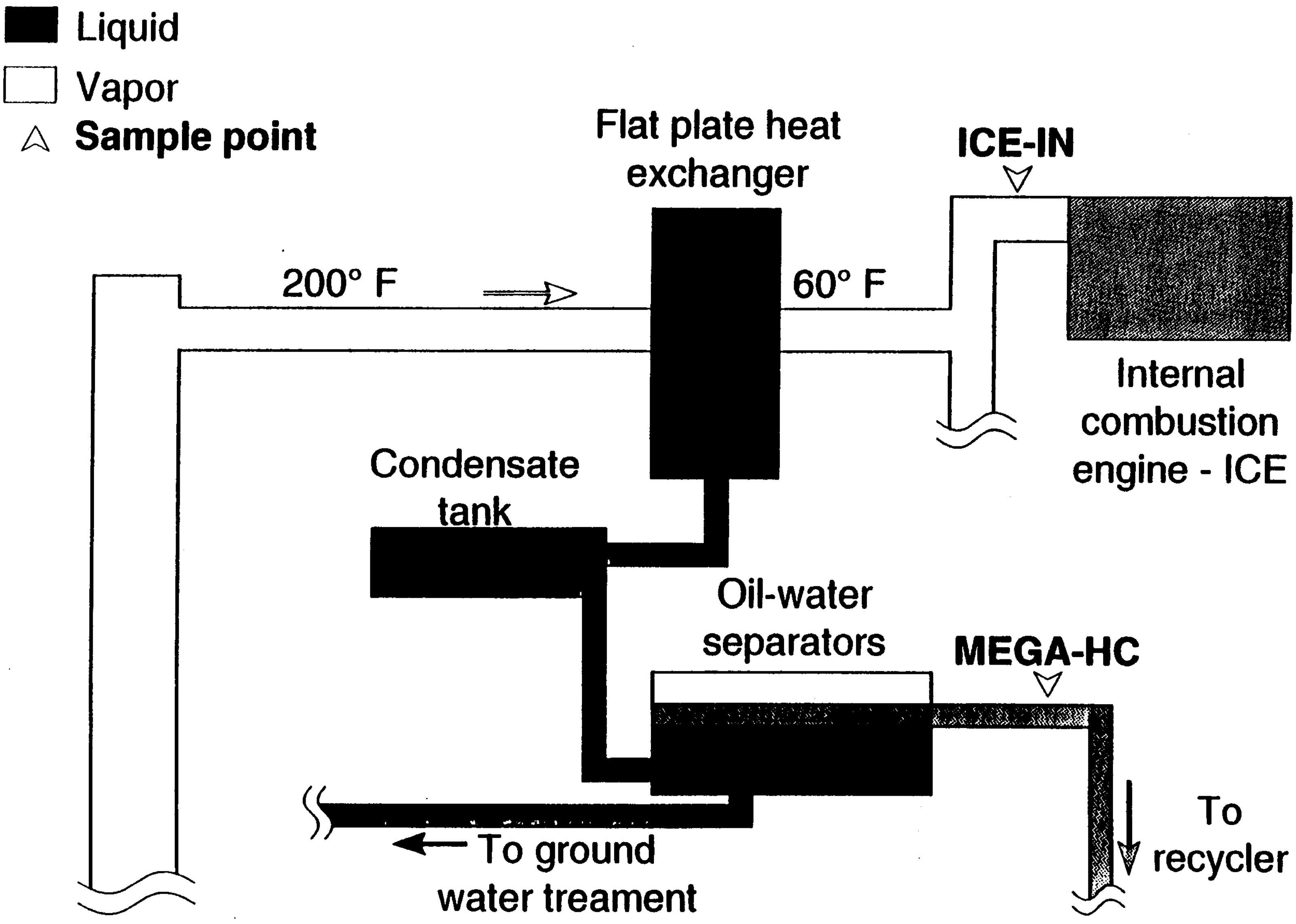


Fig. 1

Simplified schematic of vapor treatment system



■ Liquid

□ Vapor

△ **Sample point**

Flat plate heat exchanger

ICE-IN

200° F

60° F

Internal combustion engine - ICE

Condensate tank

Oil-water separators

MEGA-HC

To ground water treament

To recycler

Fig. 2

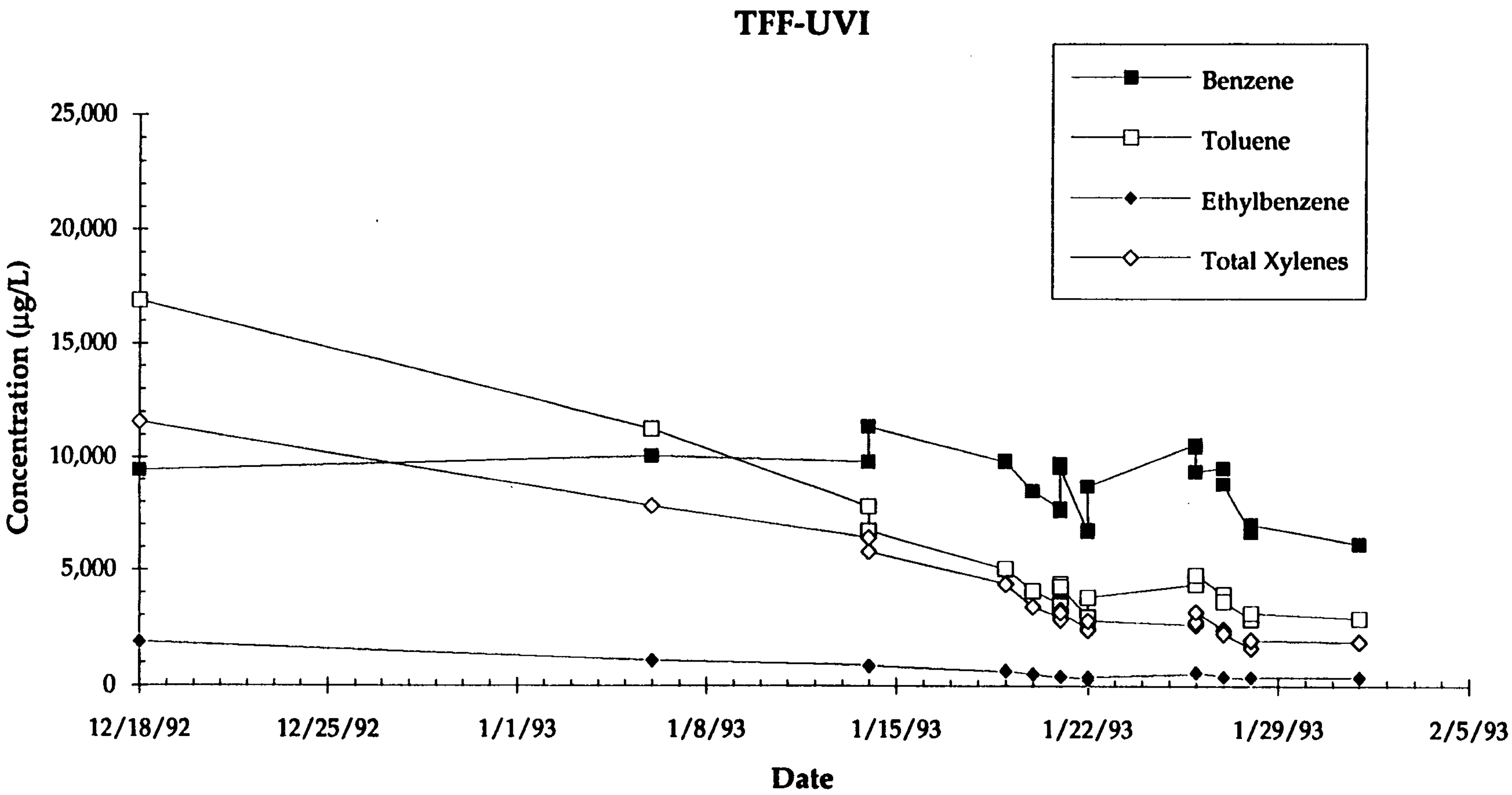


Fig. 3 - BTEX component concentrations in the UVI sampling port prior to the first steam pass.

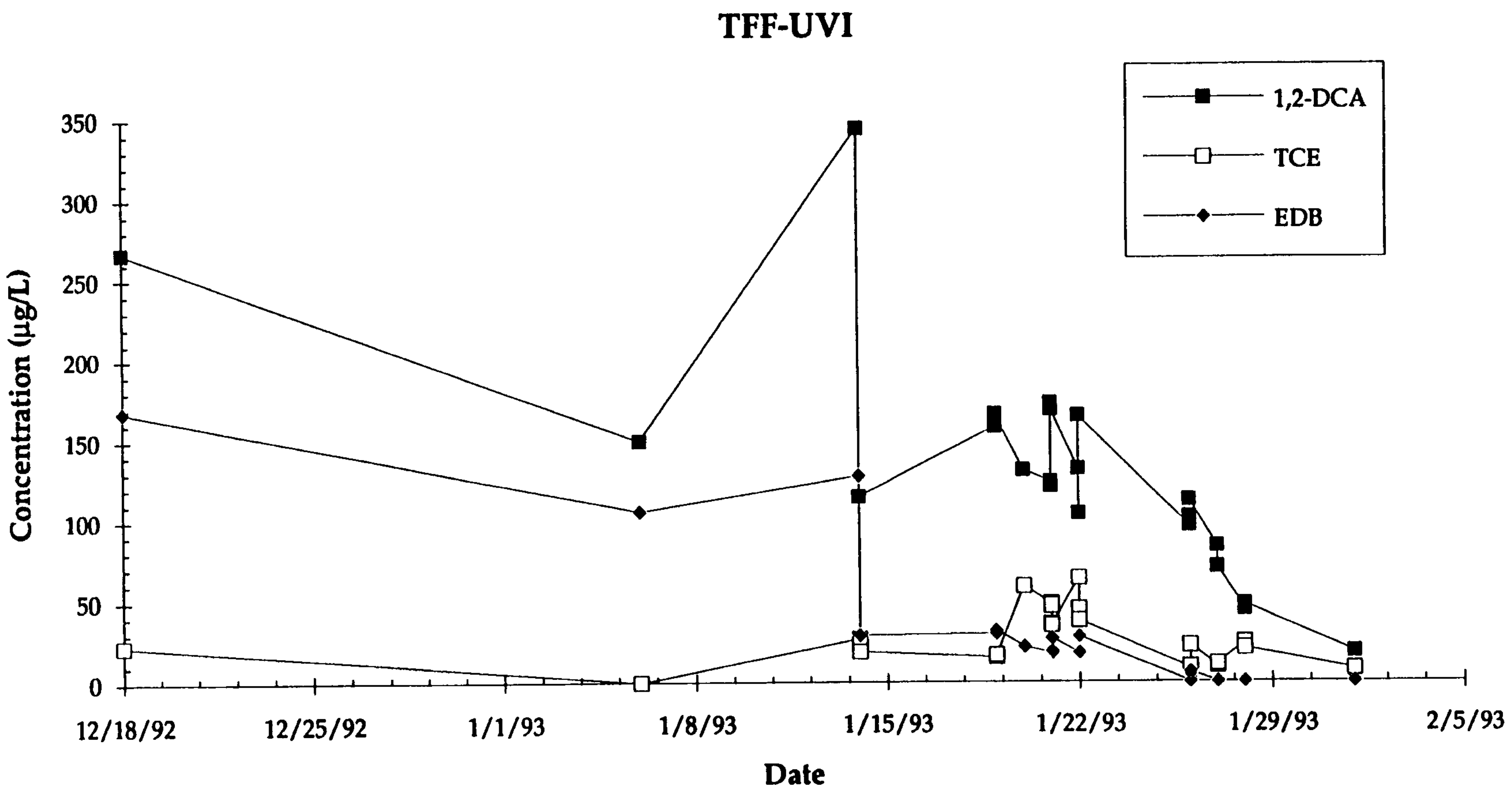


Fig. 4 - 1,2-DCA, TCE and EDB concentrations in the UVI sampling port prior to the first steam pass.

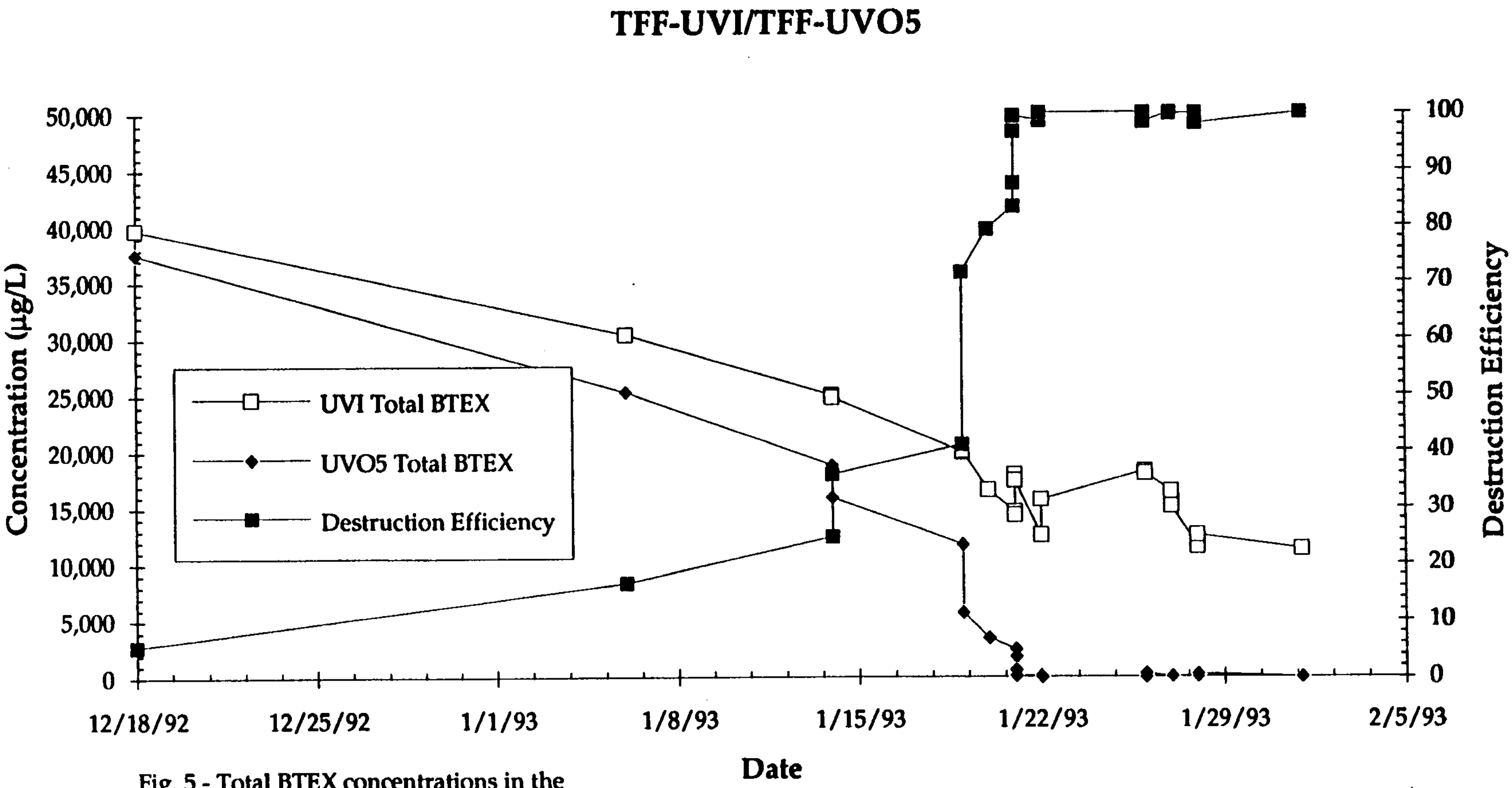


Fig. 5 - Total BTEX concentrations in the UVI and UVO5 sampling ports and UV peroxidation system destruction efficiency prior to the first steam pass.

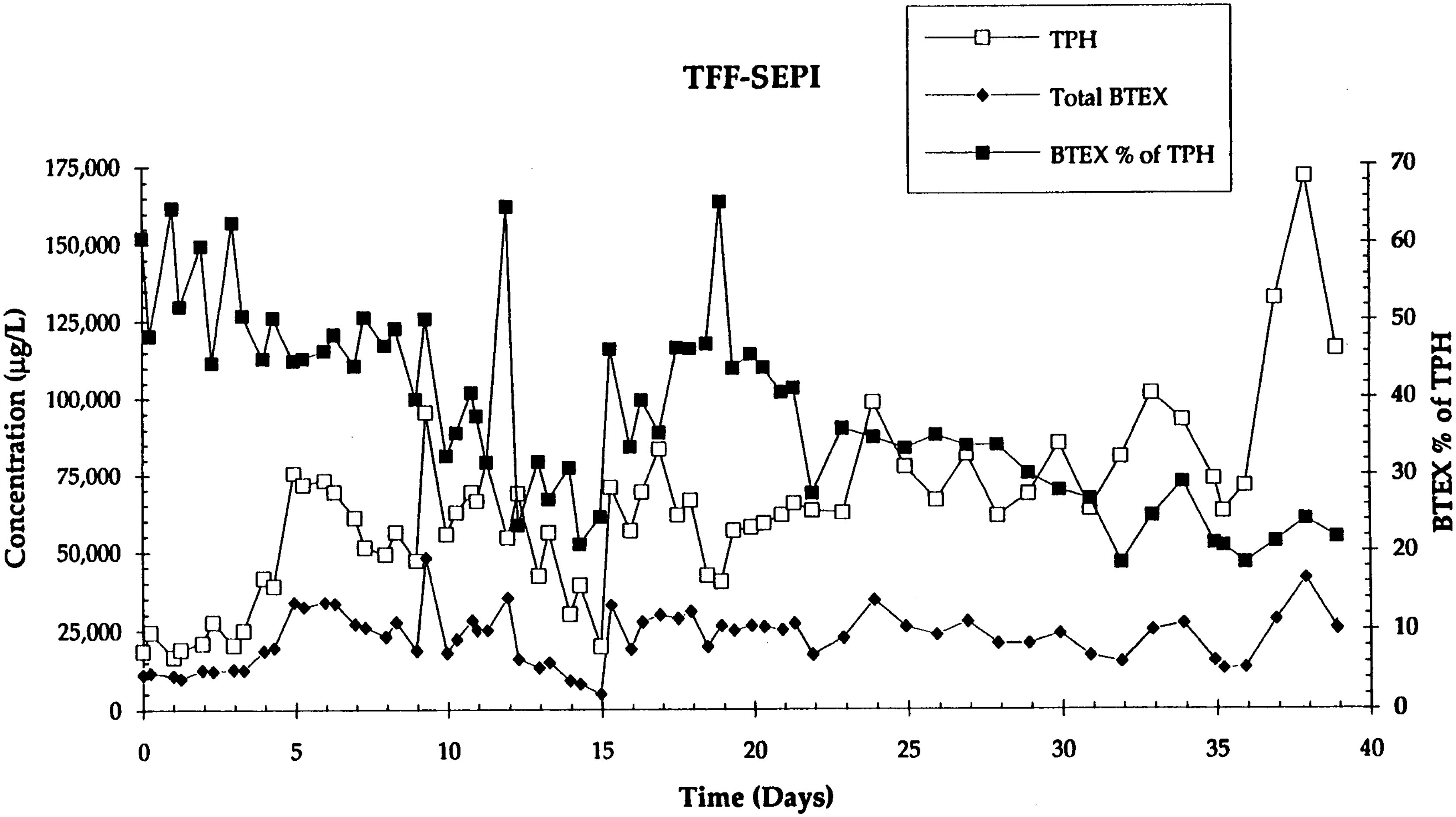


Fig. 6 - TPH and total BTEX concentrations in the SEPI sampling port during the first steam pass.

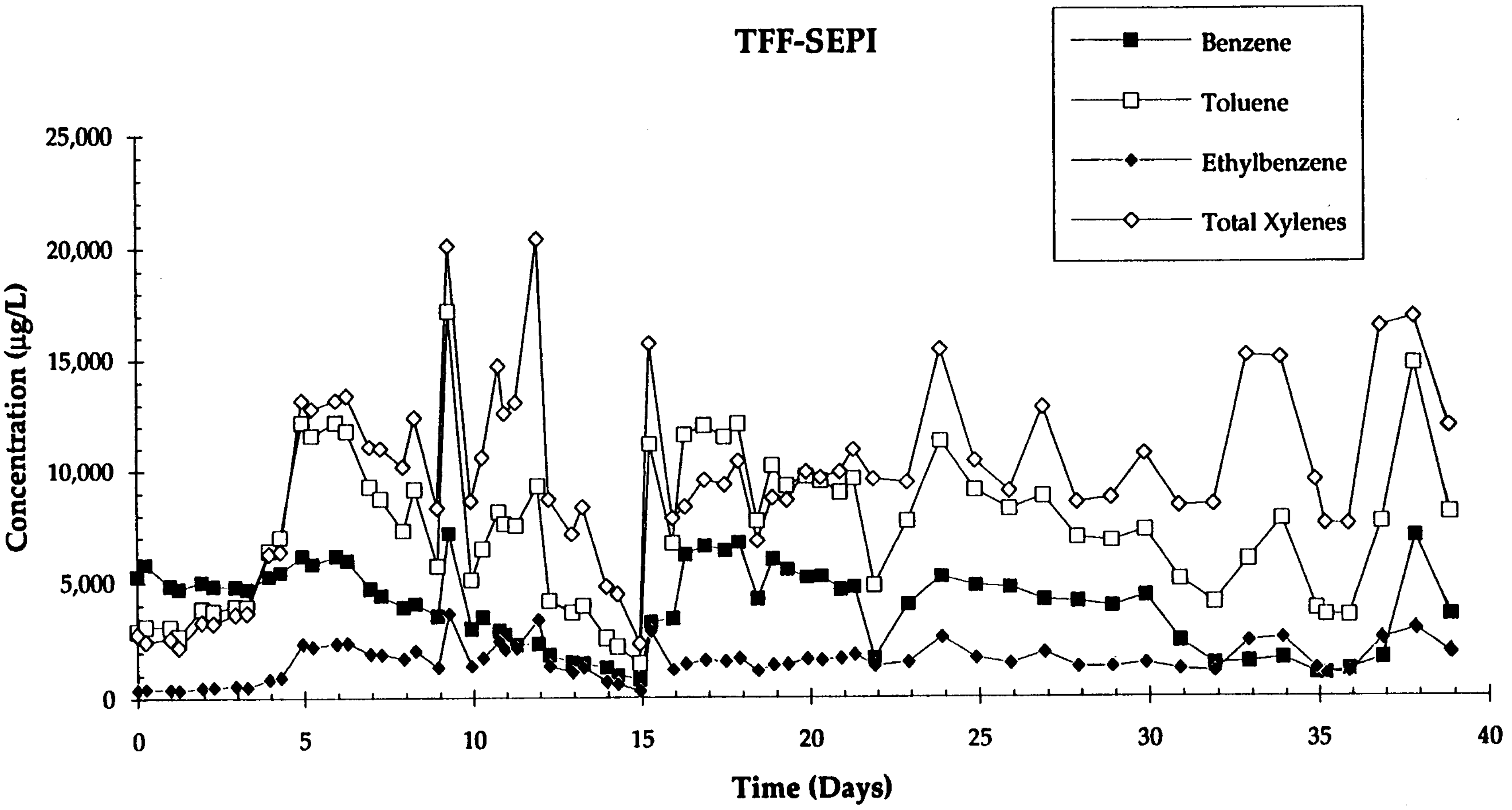


Fig. 7 - BTEX component concentrations in the SEPI port during the first steam pass.

8/12/94 - mjd

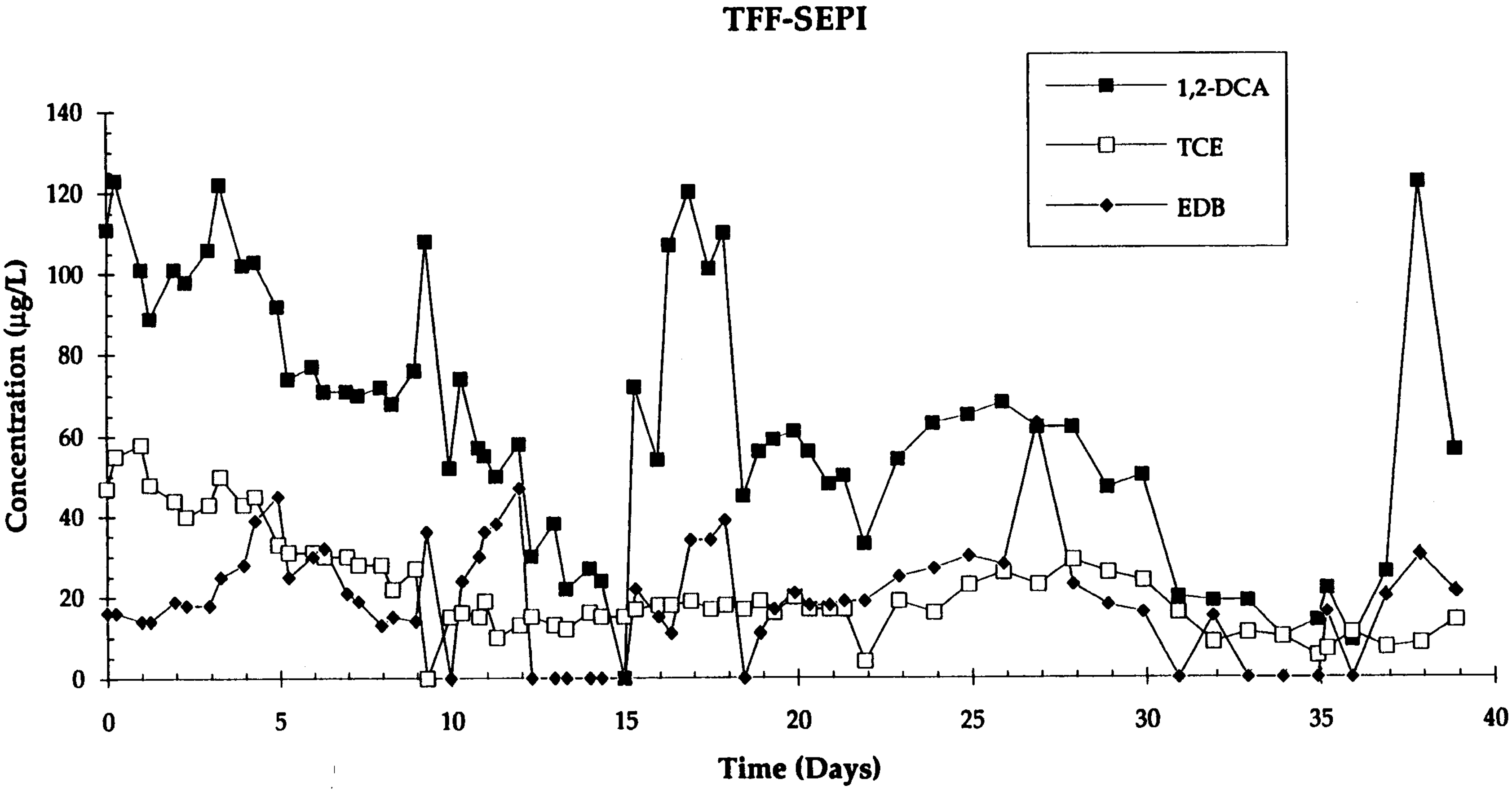


Fig. 8 - 1,2-DCA, TCE, and EDB concentrations in the SEPI sampling port during the first steam pass.

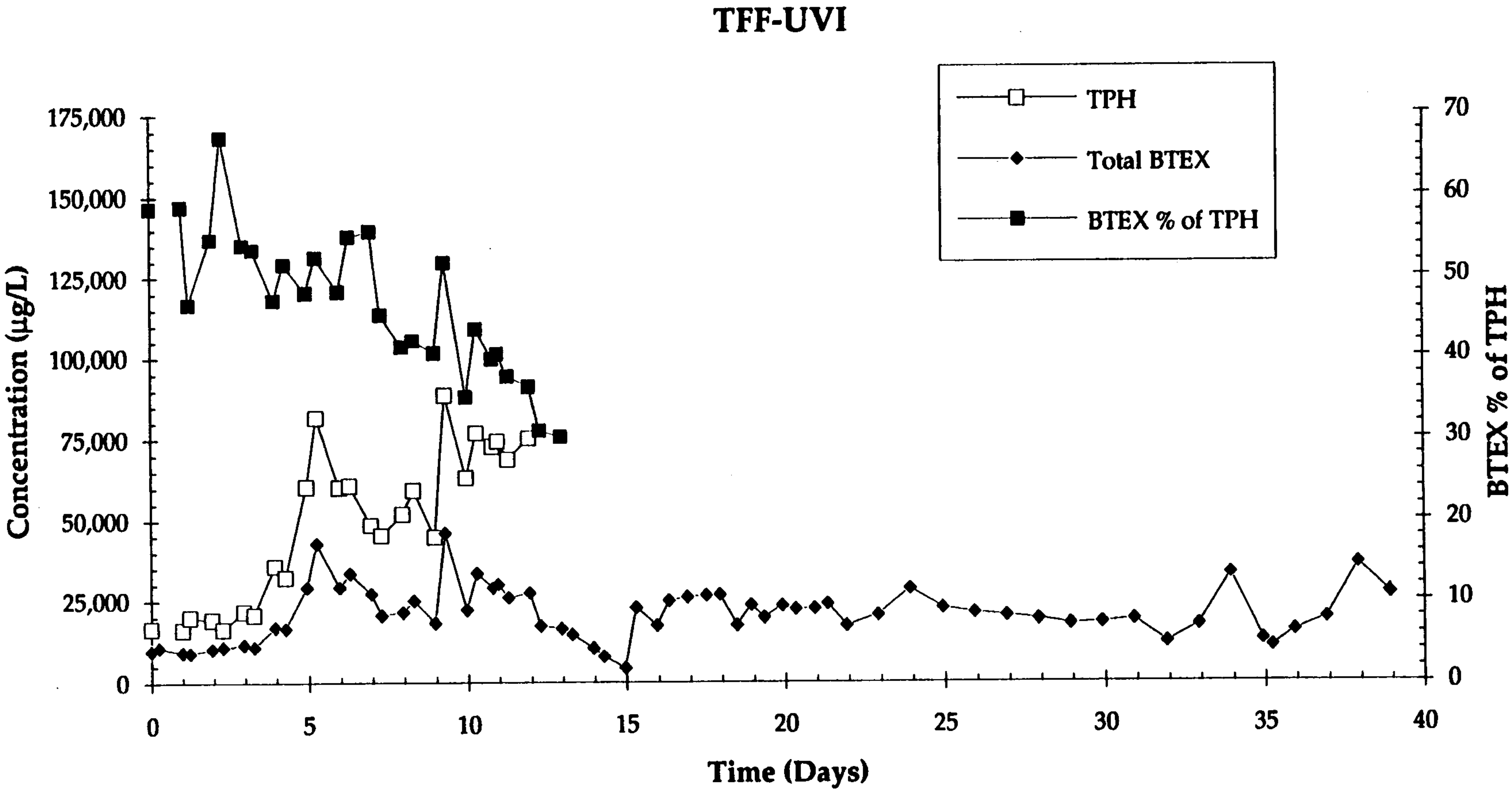


Fig. 9 - TPH and total BTEX concentrations in the UVI sampling port during the first steam pass.

8/12/94 - mjd

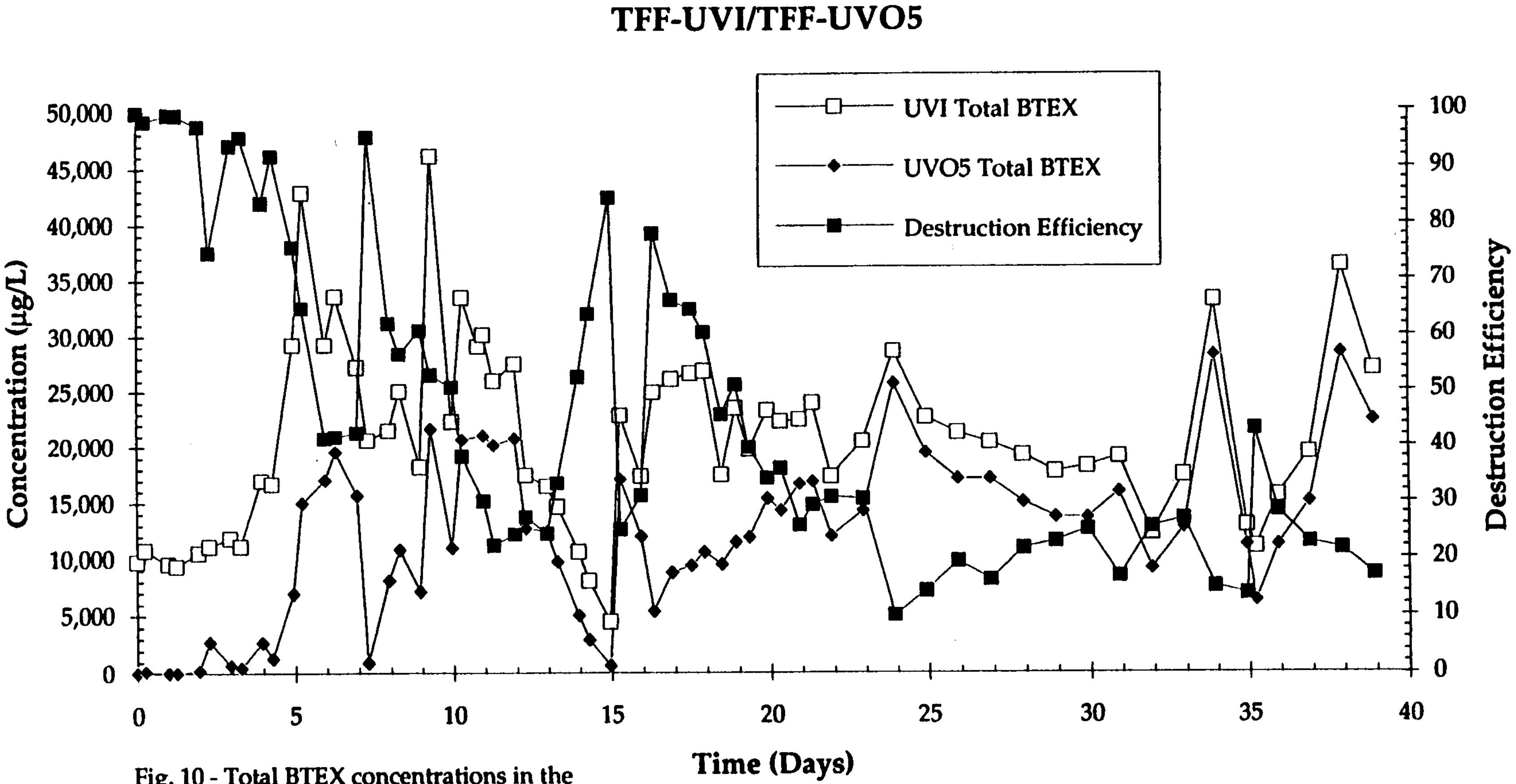


Fig. 10 - Total BTEX concentrations in the UVI and UVO5 sampling ports and UV peroxidation system destruction efficiency during the first steam pass.

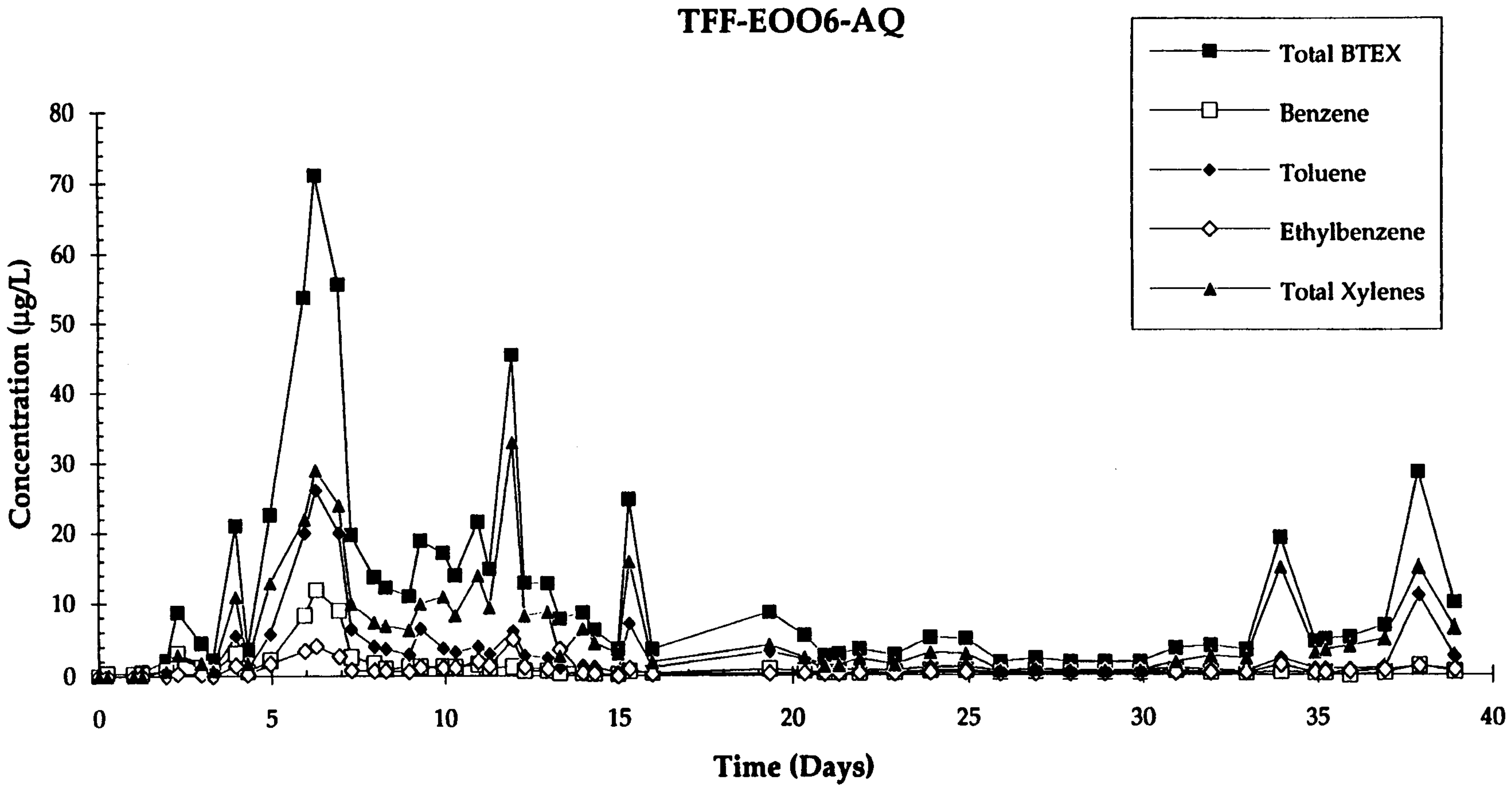


Fig. 11 - Total BTEX and BTEX component concentrations in the EOO6-AQ sampling port during the first steam pass.

8/12/94 - mjd

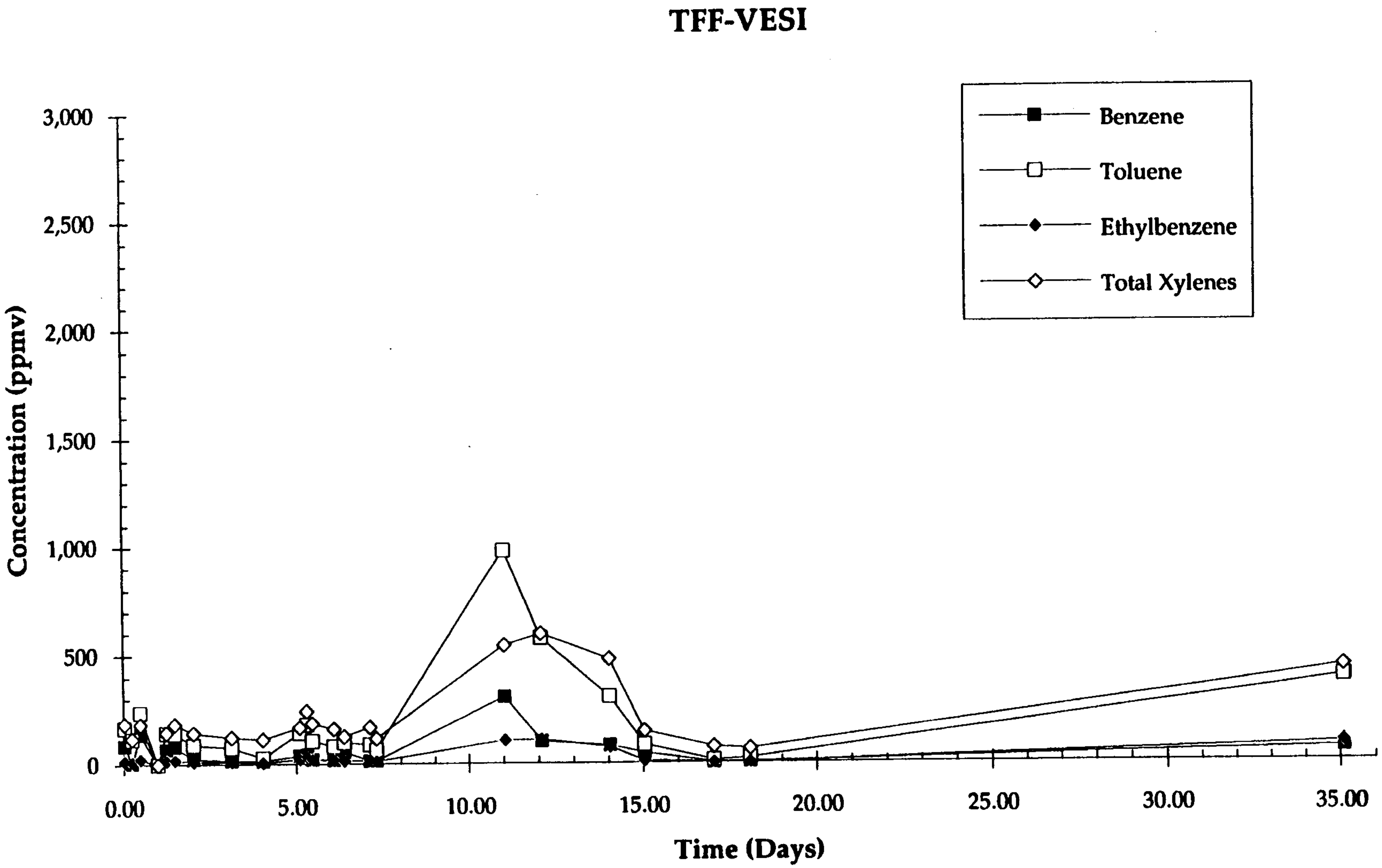


Fig. 12 - BTEX component concentrations in the VESI sampling port during the first steam pass.

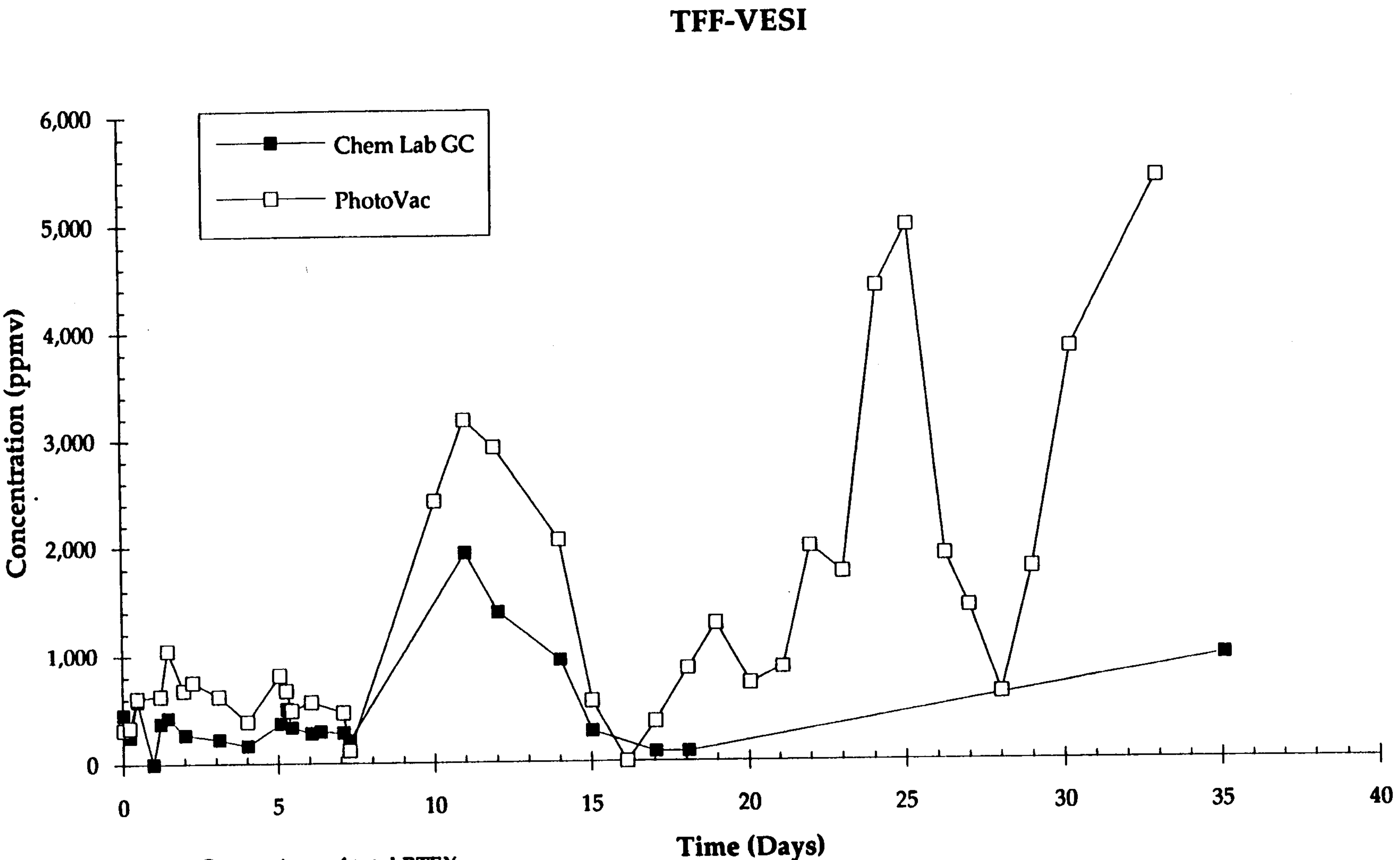


Fig. 13 - Comparison of total BTEX concentrations by GC and field photovac in the VESI sampling port during the first steam pass.

8/12/94 - mjd

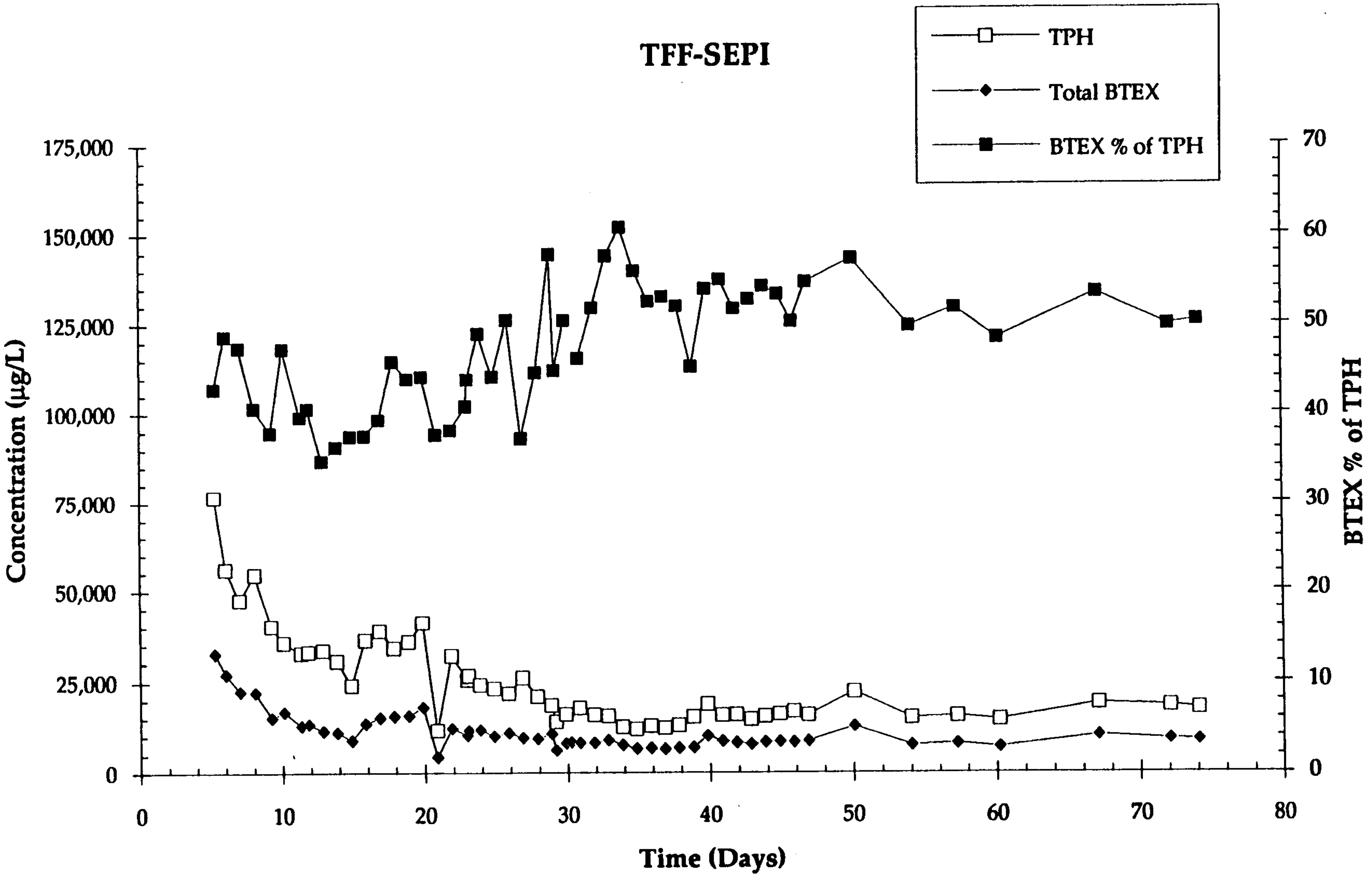


Fig. 14 - TPH and total BTEX concentrations in the SEPI sampling port during the second steam pass.

8/12/94 - mjd

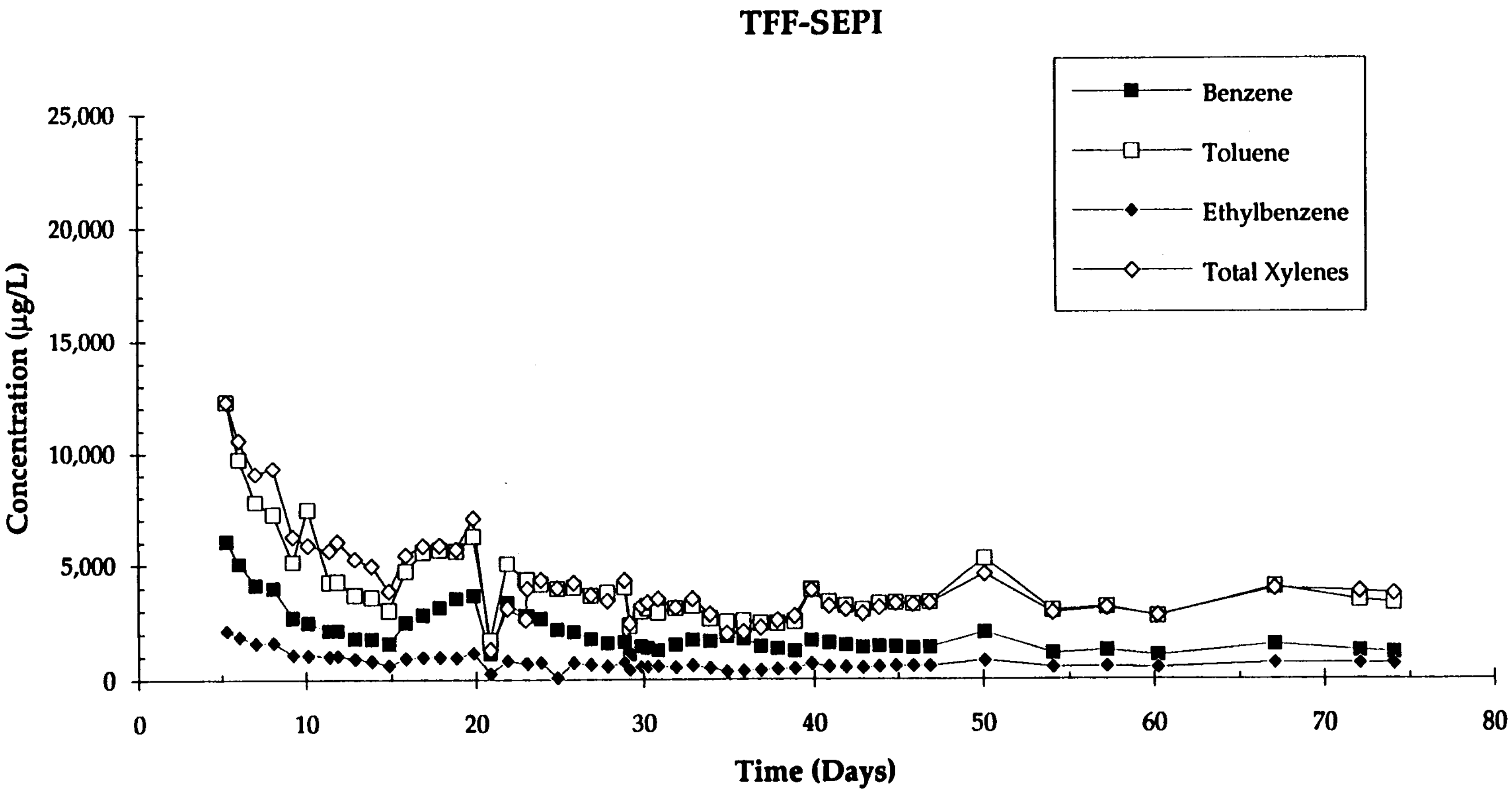


Fig. 15 - BTEX component concentrations in the SEPI sampling port during the second steam pass.

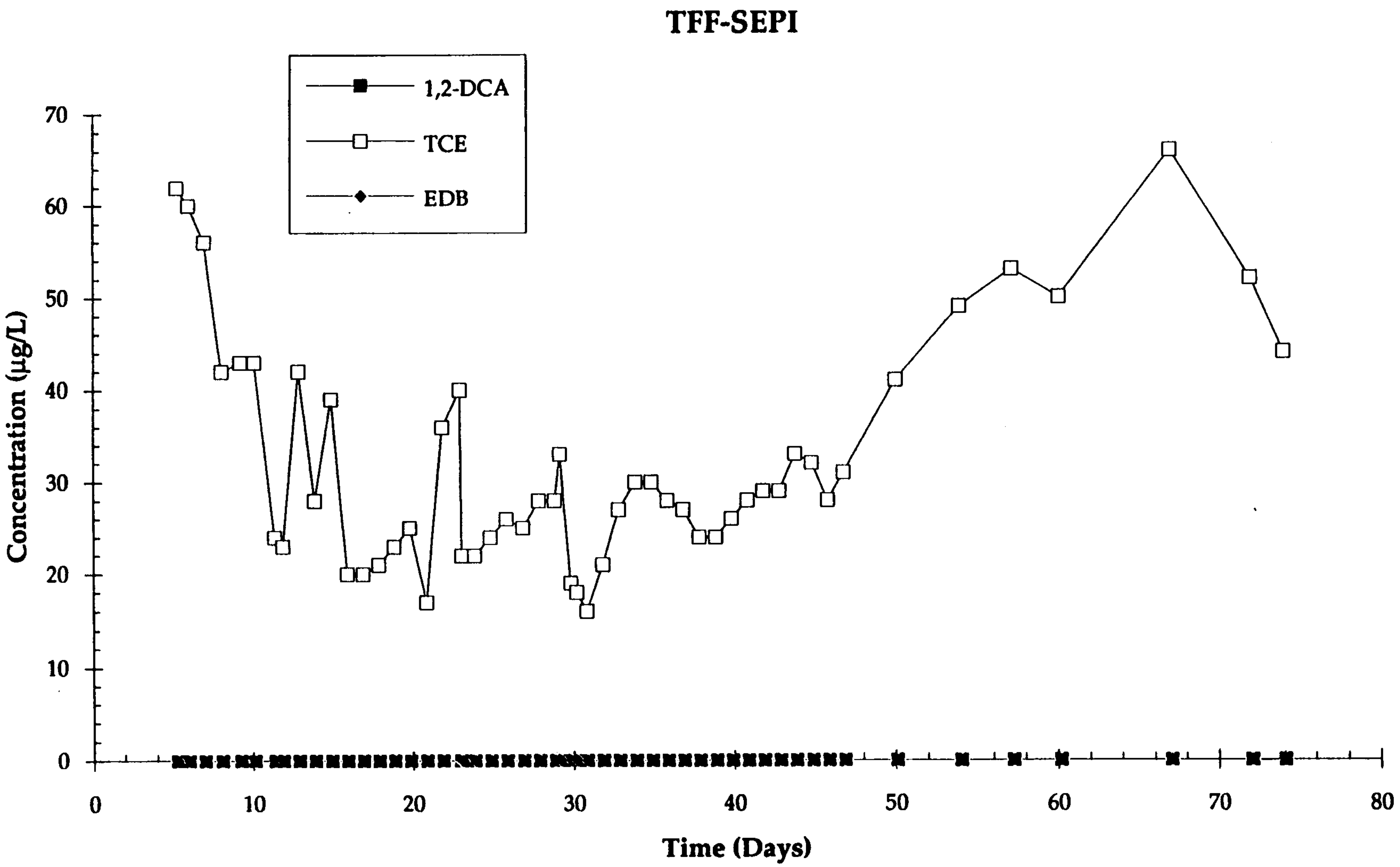


Fig. 16 - 1,2-DCA, TCE, and EDB concentrations in the SEPI sampling port during the second steam pass.

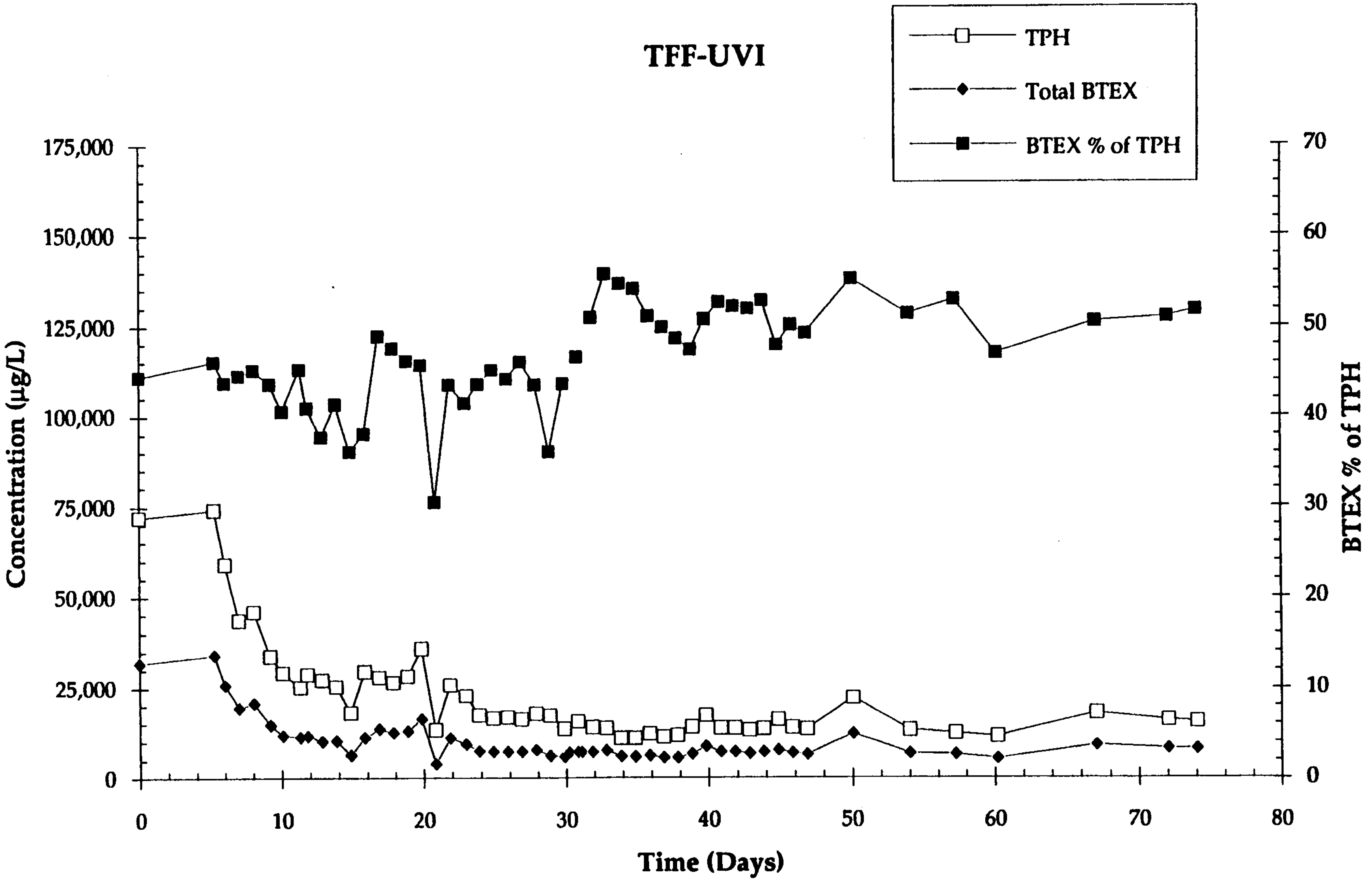


Fig. 17 - TPH and total BTEX concentrations in the UVI sampling port during the second steam pass.

8/12/94 - mjd

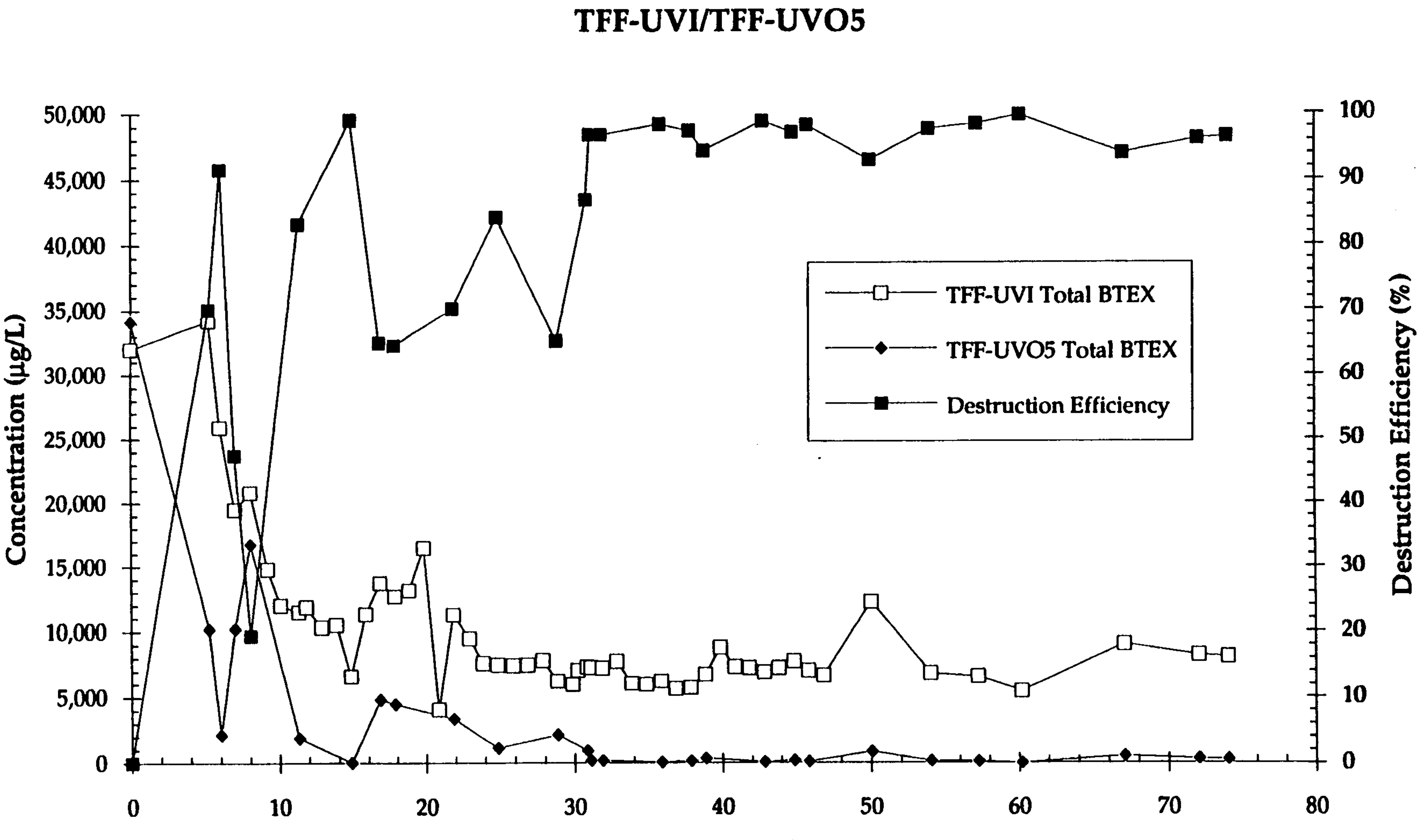


Fig. 18 - Total BTEX concentrations in the UVI and UVO5 sampling ports and UV peroxidation system destruction efficiency during the second steam pass.

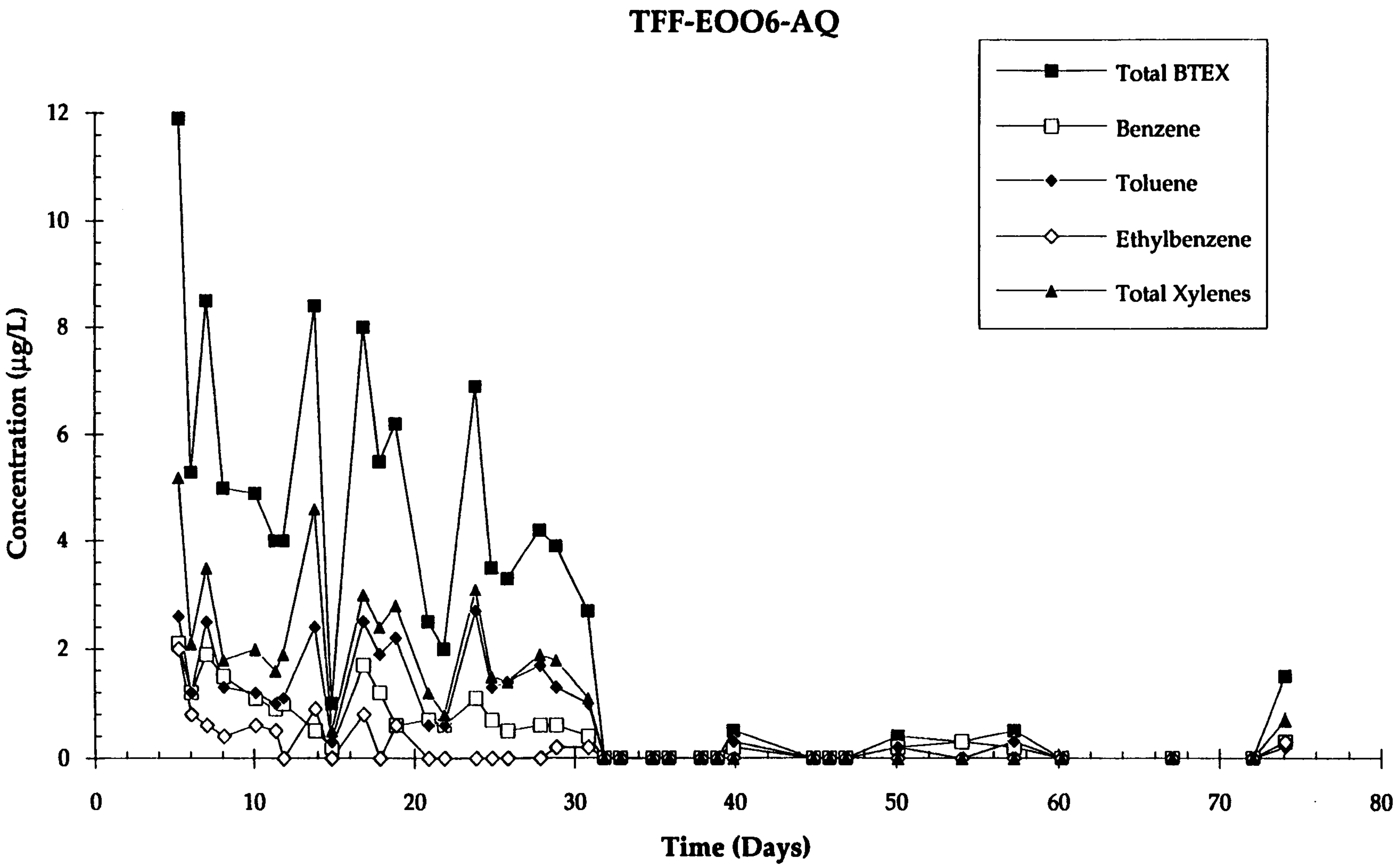


Fig. 19 - Total BTEX and BTEX component concentrations in the EOO6-AQ sampling port during the second steam pass.

8/12/94 - mjd

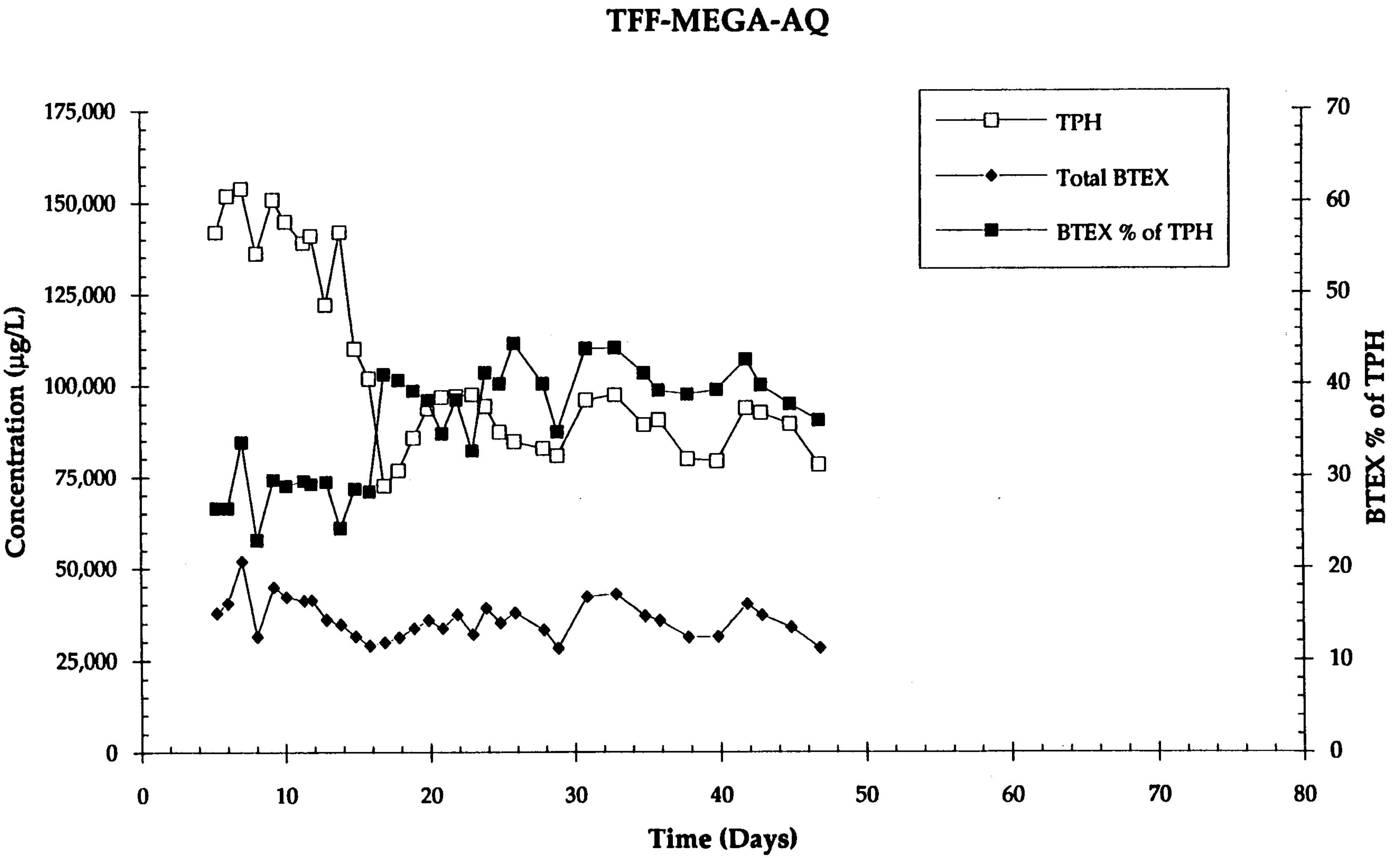


Fig. 20 - TPH and total BTEX concentrations in the MEGA-AQ sampling port during the second steam pass.

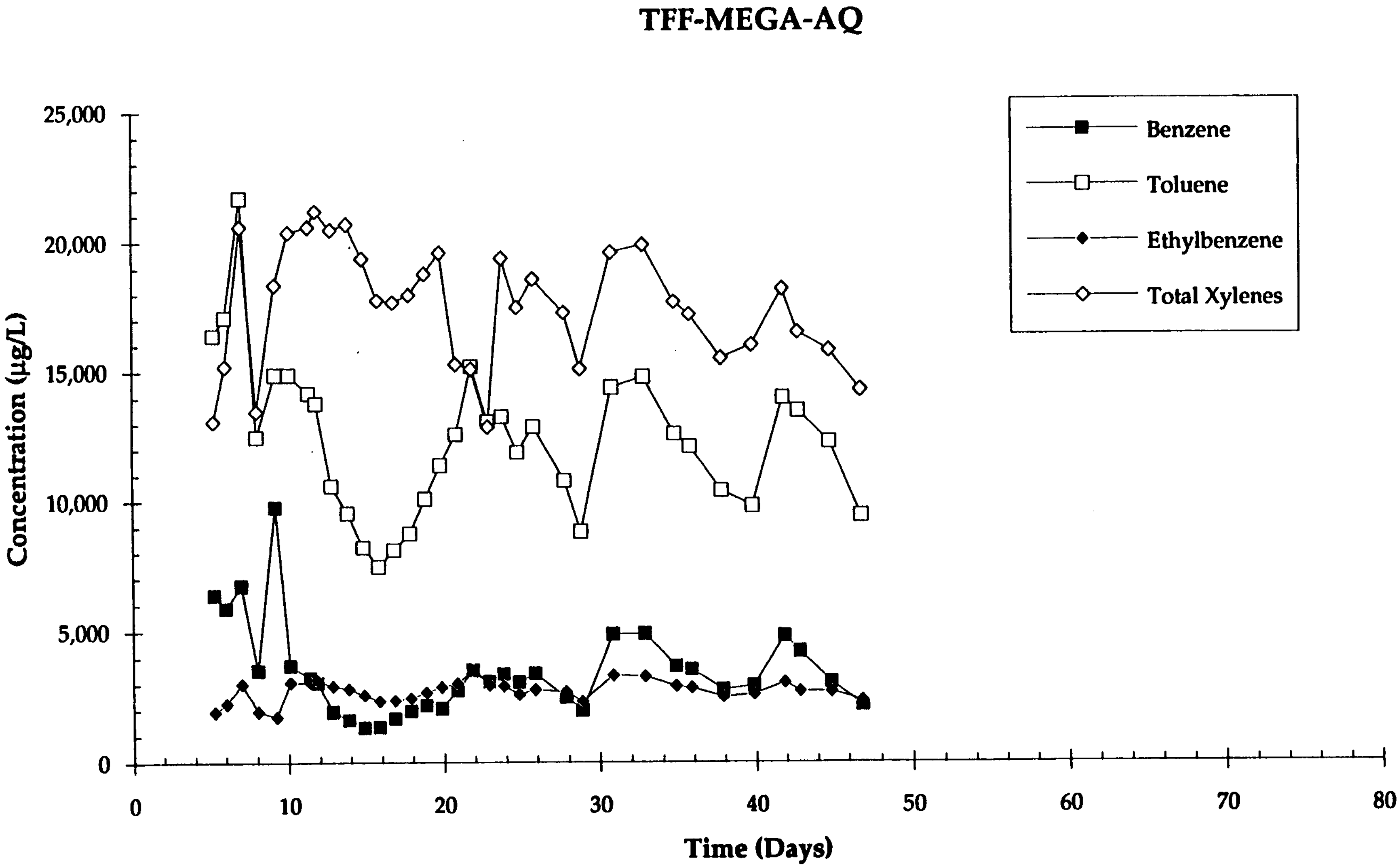


Fig. 21 - BTEX component concentrations in the MEGA-AQ sampling port during the second steam pass.

8/12/94 - mjd

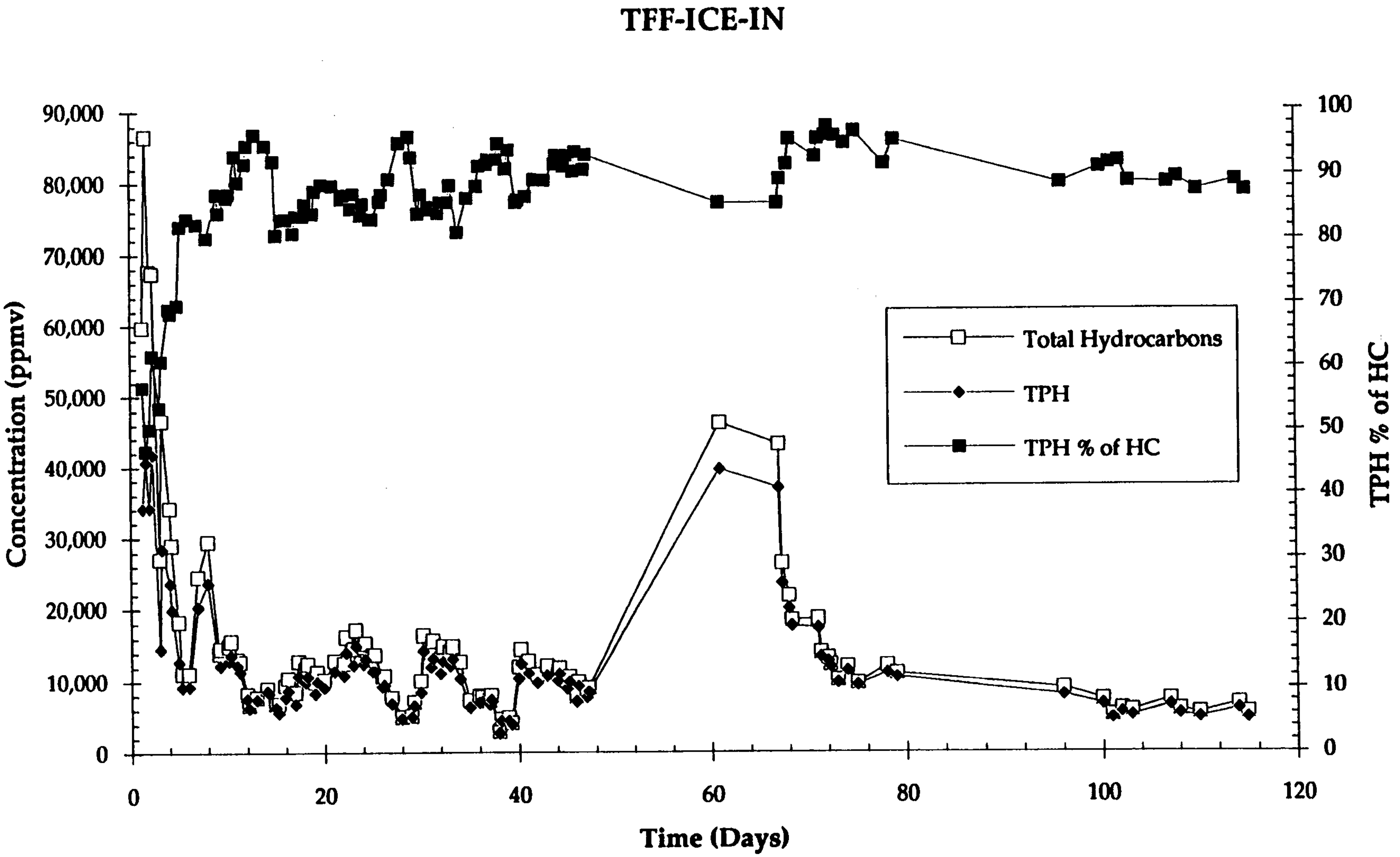


Fig. 22 - Total hydrocarbons (HC) and TPH concentrations in the ICE-IN sampling port during the second steam pass.

8/12/94 - mjd

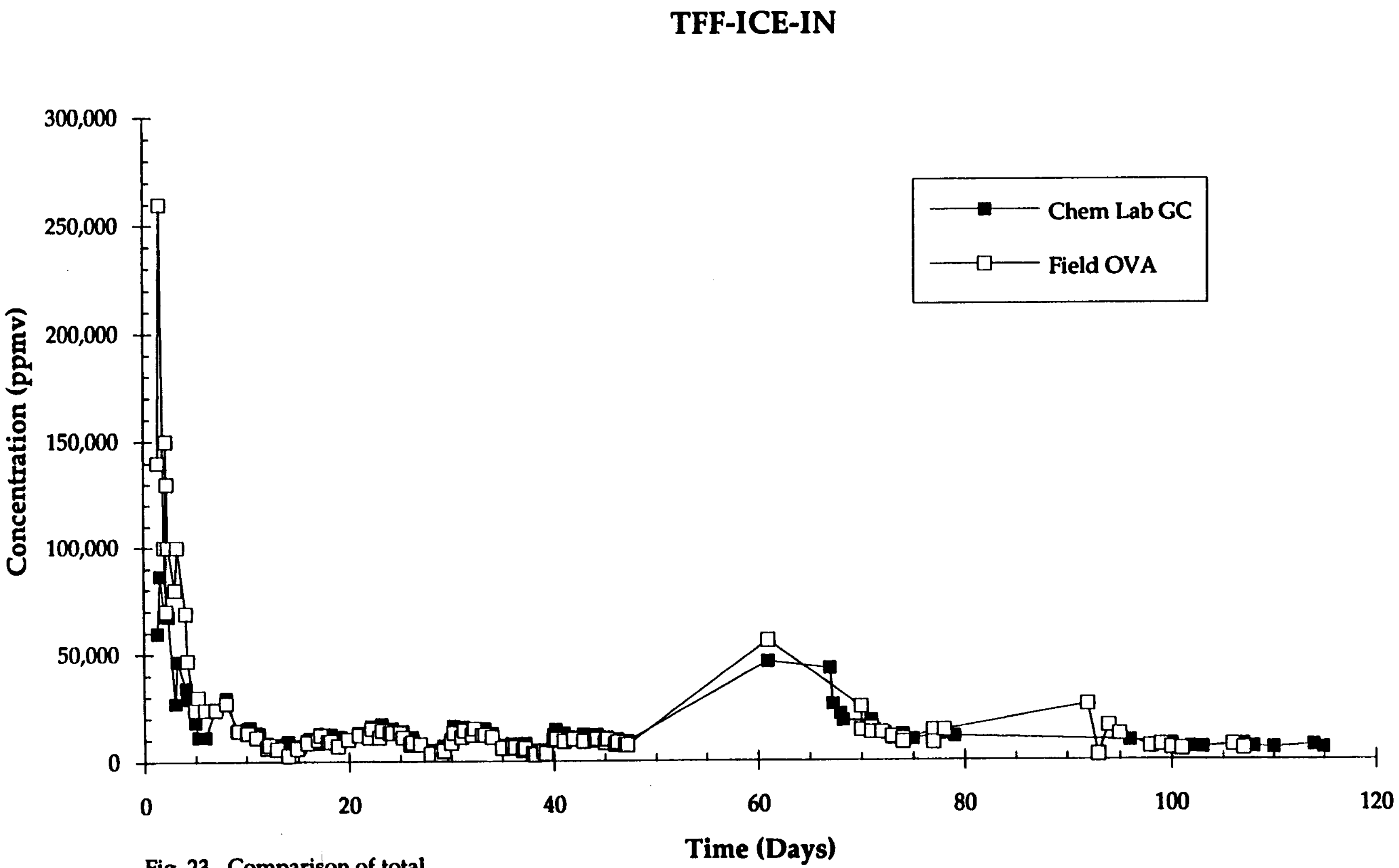


Fig. 23 - Comparison of total
hydrocarbons by GC and field OVA in the ICE-IN sampling port during the second steam pass.

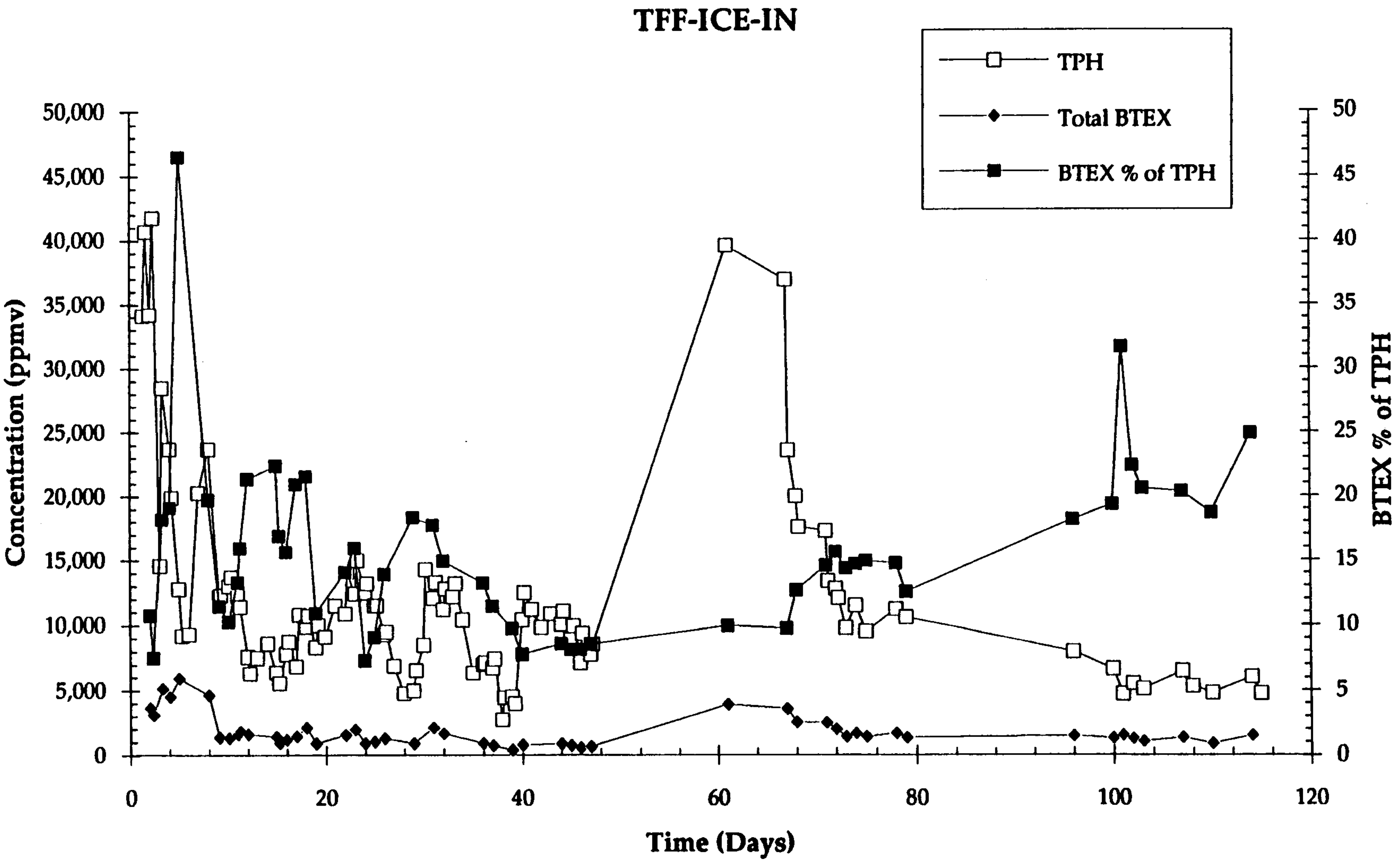


Fig. 24 - TPH and total BTEX concentrations in the ICE-IN sampling port during the second steam pass.

8/12/94 - mjd

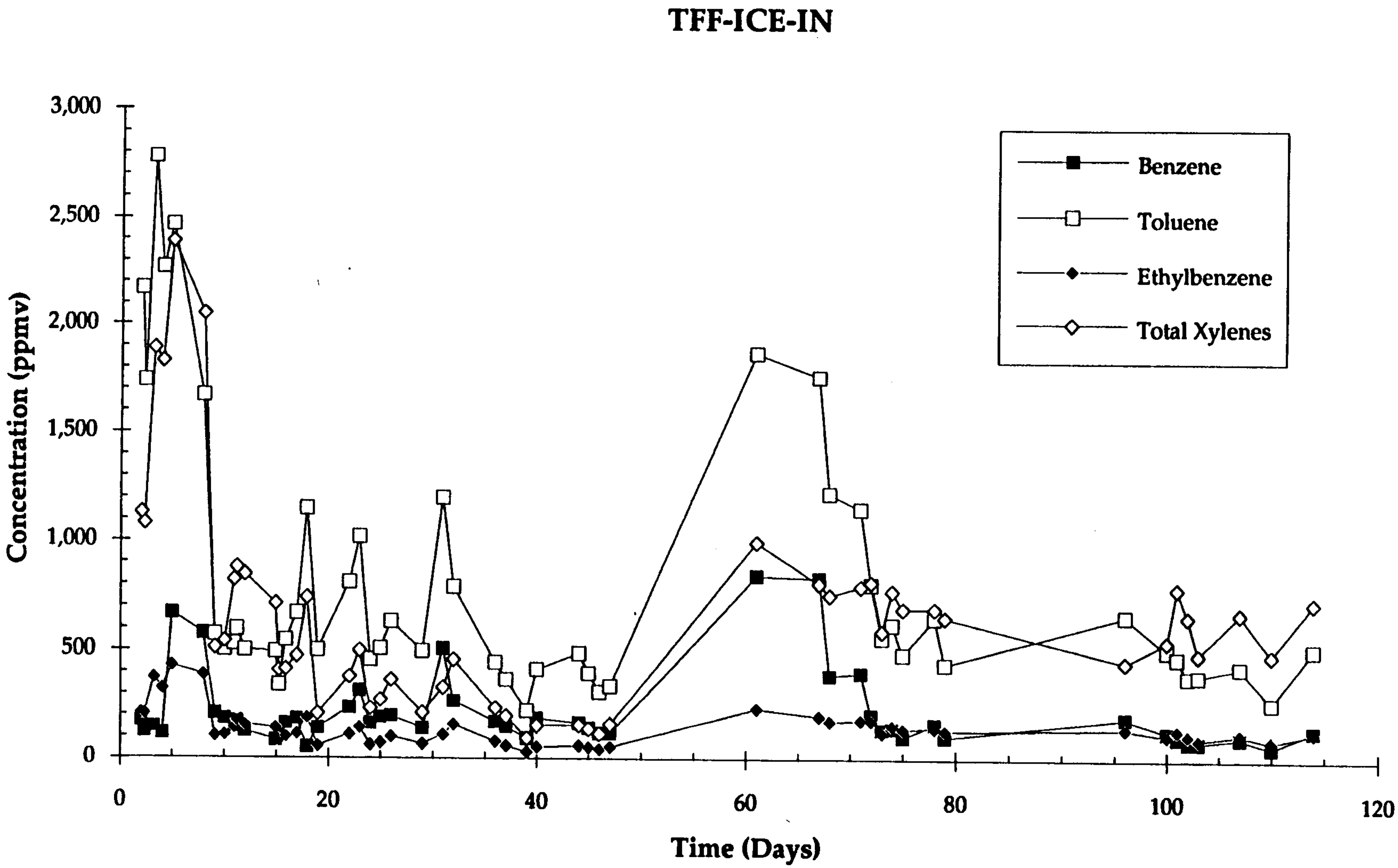


Fig. 25 - BTEX component concentrations in the ICE-IN sampling port during the second steam pass.

8/12/94 - mjd

Appendix A. Pre-DUS Baseline Aqueous Data

Date Sampled	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-IOO6-AQ							
12/18/92	39,600	42	12,300	17,600	1,330	8,330	95,400
1/6/93	29,600	•	9,490	10,100	1,310	8,740	•
TFF-SEPE							
12/18/92	39,700	35	9,510	17,100	1,810	11,300	113,000
1/6/93	30,100	•	9,940	11,300	1,080	7,740	•
2/1/93	13,100	•	6,180	3,160	410	3,340	•
2/1/93	12,300	•	6,110	2,920	374	2,930	•
TFF-UVI							
12/18/92	39,800	32	9,450	16,900	1,890	11,600	123,000
1/6/93	30,400	•	10,100	11,300	1,100	7,850	•
1/14/93	25,000	•	9,840	7,820	904	6,440	•
1/14/93	24,800	•	11,400	6,740	874	5,820	•
1/19/93	19,900	•	9,830	5,050	641	4,400	•
1/19/93	20,000	•	9,880	5,070	655	4,390	•
1/20/93	16,600	•	8,520	4,090	530	3,420	•
1/21/93	14,600	•	7,760	3,540	386	2,950	•
1/21/93	14,300	•	7,660	3,450	380	2,840	•
1/21/93	17,900	•	9,760	4,410	470	3,280	•
1/21/93	17,400	•	9,570	4,270	442	3,160	•
1/22/93	12,500	•	6,730	2,970	319	2,460	•
1/22/93	12,500	•	6,790	2,950	309	2,410	•
1/22/93	15,700	•	8,730	3,820	407	2,790	•
1/26/93	18,200	•	10,600	4,390	541	2,620	•
1/26/93	18,200	•	10,500	4,380	572	2,730	•
1/26/93	18,000	•	9,390	4,800	597	3,180	•
1/27/93	16,400	•	9,550	3,950	470	2,410	•
1/27/93	15,100	•	8,830	3,650	393	2,260	•
1/28/93	11,500	•	6,690	2,880	320	1,640	•
1/28/93	12,500	•	7,020	3,140	377	1,960	•
2/1/93	11,300	•	6,160	2,890	376	1,890	•
TFF-UVI1							
1/21/93	13,900	•	7,870	3,330	329	2,400	•
1/26/93	15,600	•	9,060	3,690	470	2,400	•
1/26/93	15,200	•	8,850	3,710	483	2,160	•
1/26/93	15,500	•	8,040	4,140	518	2,810	•
1/27/93	14,100	•	8,300	3,450	392	1,950	•
1/27/93	11,000	•	6,440	2,630	294	1,640	•

1,2-DCA µg/L	TCE µg/L	EDB µg/L
208	22	135
162	15	107
105	18	136
168	19	105
33	9.0	0.9
32	9.0	ND
267	23	168
150	ND	106
344	27	128
115	19	29
158	15	30
166	17	32
131	59	22
124	48	18
121	47	19
173	36	27
169	35	27
132	64	18
104	45	18
165	38	28
97	8.4	ND
102	9.1	4.5
112	23	6.1
84	9.5	ND
71	11	ND
45	24	ND
48	21	ND
18	7.8	ND
185	29	27
100	7.6	4.7
131	10	4.9
84	11	6.1
84	8.8	ND
69	8.9	ND

Appendix A. (Continued)

Date Sampled	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-UVO1							
1/26/93	3,880	•	2,370	905	110	492	•
1/26/93	3,250	•	1,990	765	94	398	•
1/26/93	6,250	•	3,370	1,690	206	984	•
1/27/93	4,170	•	2,580	984	108	496	•
1/27/93	4,690	•	2,800	1,090	137	660	•
1/28/93	3,820	•	2,320	928	102	473	•
1/28/93	6,210	•	3,620	1,540	195	857	•
2/1/93	1,390	•	813	351	41	185	•
TFF-UVO2							
1/26/93	546	•	320	119	15	92	•
1/26/93	284	•	168	62	7.9	46	•
1/26/93	2,050	•	1,030	511	67	438	•
1/27/93	447	•	283	101	11	52	•
1/27/93	1,820	•	1,100	426	50	241	•
1/28/93	621	•	384	146	17	74	•
1/28/93	1,980	•	1,160	483	65	270	•
2/1/93	183	•	107	44	5.8	26	•
TFF-UVO3							
1/22/93	635	•	374	143	14	104	•
1/22/93	11	•	2.6	2.5	0.6	4.8	•
1/22/93	15	•	8.1	3.0	0.6	2.9	•
1/26/93	25	•	14	5.0	0.7	4.9	•
1/26/93	12	•	7.6	2.6	ND	2.0	•
1/26/93	817	•	424	204	26	164	•
1/27/93	17	•	10	4.0	ND	3.0	•
1/27/93	285	•	169	62	7.0	47	•
1/28/93	98	•	56	20	3.0	19	•
1/28/93	633	•	358	145	19	111	•
2/1/93	5.6	•	2.0	1.2	ND	2.4	•
TFF-UVO5							
12/18/92	37,600	31	8,730	15,700	1,860	11,300	120,000
1/6/93	25,300	•	8,500	9,210	961	6,630	•
1/14/93	18,800	•	7,890	5,840	667	4,360	•
1/14/93	15,900	•	7,960	4,300	537	3,110	•
1/19/93	11,700	•	6,390	2,940	349	2,070	•
1/19/93	5,670	•	3,110	1,430	142	984	•
1/20/93	3,420	•	2,040	842	64	472	•
1/21/93	2,430	•	1,560	560	23	289	•
1/21/93	1,770	•	1,160	433	18	159	•

1,2-DCA µg/L	TCE µg/L	EDB µg/L
104	3.6	5.7
96	2.9	4.7
92	10	6.7
70	ND	ND
60	ND	ND
52	6.0	ND
60	8.7	ND
9.1	ND	ND
102	2.0	11
111	1.0	10
109	14	17
93	1.5	8.0
94	10	9.0
76	7.0	6.0
86	18	7.0
61	0.6	3.0
105	8.0	13
64	ND	6.5
89	ND	10
80	ND	5.5
81	ND	3.4
113	6.1	13
71	ND	4.0
89	2.0	8.0
69	0.8	4.0
79	8.0	5.0
48	ND	1.8
157	7	156
148	ND	105
198	6.5	84
110	10	31
187	8.2	27
178	6.8	26
124	10	11
136	13	ND
128	7.4	ND

Appendix A. (Continued)

Date Sampled	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-UVO5 (Continued)							
1/21/93	590	•	360	138	11	81	•
1/21/93	81	•	52	16	1.9	11	•
1/22/93	162	•	98	34	4.3	26	•
1/22/93	3.8	•	0.8	1.4	ND	1.6	•
1/22/93	0.7	•	ND	ND	ND	0.7	•
1/26/93	ND	•	ND	ND	ND	ND	•
1/26/93	2.2	•	0.6	0.6	ND	1.0	•
1/26/93	287	•	149	69	8.5	60	•
1/27/93	ND	•	ND	ND	ND	ND	•
1/27/93	32	•	19	7.0	0.7	5.0	•
1/28/93	13	•	8.2	2.8	ND	1.7	•
1/28/93	239	•	137	54	7.0	41	•
2/1/93	ND	•	ND	ND	ND	ND	•
TFF-EOO6-AQ							
1/28/93	ND	•	ND	ND	ND	ND	•
1/28/93	0.9	•	0.9	ND	ND	ND	•
2/1/93	20	•	9.2	4.0	0.5	5.8	•
2/1/93	20	•	10	4.1	0.5	5.1	•
TFF-E1							
1/6/93	1.3	•	ND	1.3	ND	ND	•
1/26/93	ND	•	ND	ND	ND	ND	•
1/26/93	6.2	•	ND	0.7	4.0	1.5	•
1/26/93	4.8	•	ND	ND	3.5	1.3	•
1/27/93	ND	•	ND	ND	ND	ND	•
1/27/93	ND	•	ND	ND	ND	ND	•
TFF-EW-COND							
1/19/93	727	•	128	237	32	330	•
1/20/93	379	•	56	131	14	178	•
TFF-BT-1961							
12/17/92	692	28	115	295	41	241	2,500
12/18/92	9.0	2	1.0	4.0	1.0	3.0	518
12/28/92	155	10	25	72	7.0	51	1,560
1/7/93	ND	•	ND	ND	ND	ND	•
1/14/93	1.6	•	ND	0.6	1.0	ND	•
1/19/93	8.8	•	2.4	1.8	1.0	3.6	•
1/20/93	154	•	92	34	1.1	27	•
1/21/93	10	•	5.4	1.6	ND	3.3	•
1/22/93	14	•	7.4	1.6	ND	5.1	•

1,2-DCA µg/L	TCE µg/L	EDB µg/L
133	4.7	15
126	1.4	14
92	2.3	10
34	ND	3.0
78	ND	6.5
48	ND	ND
44	ND	1.9
109	1.7	12
44	ND	2.0
72	ND	4.0
66	ND	3.5
70	1.0	4.0
25	ND	ND
ND	ND	ND
0.6	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
1.4	ND	2.9
1.5	ND	1.8
7.0	ND	20
3.0	ND	9.0
4.3	ND	ND
ND	ND	ND
ND	ND	ND
6.3	1.0	5.7
26	ND	6.4
10	ND	2.9
11	ND	3.2

Appendix A. (Continued)

Date Sampled	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-BT-1962							
1/13/93	ND	•	ND	ND	ND	ND	•
1/15/93	15	•	3.0	3.3	1.9	6.8	•
1/19/93	213	•	119	51	1.7	41	•
1/19/93	28	•	13	5.4	1.1	8.3	•
1/21/93	5.0	•	1.0	1.0	2.0	1.0	•
1/22/93	ND	•	ND	ND	ND	ND	•
1/25/93	ND	•	ND	ND	ND	ND	•
2/2/93	ND	•	ND	ND	ND	ND	•

• Indicates analysis not performed.

ND: Not detected at or above limit of detection.

*Total Petroleum Hydrocarbons (Window: C6 to C12).

1,2-DCA µg/L	TCE µg/L	EDB µg/L
ND	ND	ND
ND	ND	2.8
33	ND	9.4
18	ND	5.3
ND	0.9	4.0
ND	ND	ND
ND	ND	ND
ND	ND	ND

Appendix B. Pre-DUS Baseline Vapor Data

Date Sampled	Test Elapsed Time min	Total BTEX ppmv	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv	1,2-DCA ppmv	TCE ppmv	EDB ppmv
TFF-GSW-016									
8/7/92	5	221	81	110	6.0	24	•	ND	•
8/7/92	360	464	92	236	26	110	•	ND	•
TFF-GEW-808									
8/6/92	5	470	80	206	28	156	•	ND	•
8/6/92	360	59	15	44	ND	ND	•	ND	•
TFF-GEW-816									
8/4/92	5	1,810	553	1,120	17	123	•	ND	•
8/4/92	360	5,300	1,160	3,490	132	515	•	ND	•
8/5/92	5	4,180	1,240	2,560	72	307	•	80	•
8/5/92	360	3,970	799	2,820	62	287	•	ND	•
10/24/92	5	1,930	562	721	54	597	•	ND	•
10/24/92	30	2,790	752	1,080	102	856	•	ND	•
10/24/92	60	561	65	213	27	256	•	ND	•
10/24/92	180	521	58	207	25	231	•	ND	•
10/24/92	360	3,980	962	1,590	175	1,250	•	ND	•
11/21/92	5	2,120	729	774	64	558	•	•	•
11/21/92	30	1,720	753	664	35	270	•	•	•
11/21/92	60	2,400	814	883	87	616	•	•	•
11/21/92	180	655	92	239	50	274	•	•	•
11/21/92	360	2,630	842	990	106	690	•	•	•
11/21/92	480	2,720	913	1,100	99	607	•	•	•
11/21/92	481.5	3,140	956	1,300	90	793	•	•	•
11/21/92	566	3,780	1,060	1,410	215	1,100	•	•	•
TFF-HW-GP-002									
12/4/92	5	5.2	ND	1.0	ND	4.2	•	•	•
12/4/92	8	18	ND	4.2	1.5	12	•	•	•
12/4/92	30	18	ND	4.2	1.4	12	•	•	•
12/4/92	34	15	ND	3.6	1.5	9.8	•	•	•
12/4/92	60	15	ND	4.2	1.2	10	•	•	•
TFF-GIW-818									
12/4/92	5	ND	ND	ND	ND	ND	•	•	•
12/4/92	8	1.4	ND	ND	ND	1.4	•	•	•
12/4/92	30	2.9	1.1	ND	ND	1.8	•	•	•
12/4/92	34	1.4	ND	ND	ND	1.4	•	•	•
12/4/92	60	2.2	ND	ND	ND	2.2	•	•	•
12/4/92	64	3.6	ND	ND	ND	3.6	•	•	•
12/4/92	120	11	1.3	ND	1.2	8.9	•	•	•
TFF-VESI									
1/13/93	5	39	3.6	6.3	3.2	26	•	ND	•
1/13/93	30	36	2.5	6.6	2.1	25	•	ND	•
1/13/93	60	36	2.2	7.7	2.1	24	•	ND	•
1/13/93	120	44	3.1	9.5	2.6	29	•	ND	•
TFF-EOO6									
1/13/93	60	ND	ND	ND	ND	ND	•	ND	•
1/13/93	120	ND	ND	ND	ND	ND	•	ND	•

Appendix B. (Continued)

Date Sampled	Test Elapsed Time min	Total BTEX ppmv	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv	1,2-DCA ppmv	TCE ppmv	EDB ppmv
TFF-CFO									
2/1/93	60	2.2	2.2	ND	ND	ND	ND	ND	ND
2/1/93	90	3.3	3.3	ND	ND	ND	ND	ND	ND

• Indicates analysis not performed.

ND: Not detected at or above limit of detection.

Appendix C. DUS 1st Pass Aqueous Data

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-GST								
2/9/93	5.96	5,370	29	945	1,460	194	2,770	18,300
2/10/93	6.96	23,500	79	4,460	14,700	884	3,500	29,600
2/23/93	19.92	20,500	23	1,590	4,870	840	13,200	89,100
TFF-IOO6-AQ								
3/10/93	35.21	12,400	22	905	3,260	967	7,290	57,100
TFF-SEPI								
2/3/93	0.00	11,300	61	5,270	2,900	365	2,780	18,600
2/3/93	0.25	11,800	48	5,810	3,110	421	2,450	24,500
2/4/93	1.00	10,900	64	4,870	3,070	402	2,590	16,900
2/4/93	1.25	9,980	52	4,710	2,670	368	2,230	19,200
2/5/93	1.96	12,600	60	5,020	3,850	485	3,270	21,100
2/5/93	2.29	12,300	45	4,850	3,730	501	3,240	27,600
2/6/93	2.96	12,900	63	4,820	3,950	551	3,620	20,600
2/6/93	3.29	12,800	51	4,700	3,920	496	3,670	25,200
2/7/93	3.96	18,800	45	5,250	6,420	839	6,290	41,600
2/7/93	4.29	19,800	51	5,440	7,040	909	6,380	39,200
2/8/93	4.96	33,900	45	6,180	12,200	2,350	13,200	75,600
2/8/93	5.25	23,400	33	5,830	11,600	2,220	12,800	71,800
2/9/93	5.96	33,900	46	6,180	12,200	2,350	13,200	73,400
2/9/93	6.29	33,600	48	5,990	11,800	2,370	13,400	69,500
2/10/93	6.96	27,000	44	4,710	9,300	1,920	11,100	61,100
2/10/93	7.29	26,100	51	4,410	8,760	1,900	11,000	51,600
2/11/93	7.96	23,100	47	3,890	7,300	1,720	10,200	49,200
2/11/93	8.29	27,700	49	4,050	9,170	2,050	12,400	56,400
2/12/93	8.96	18,900	40	3,510	5,710	1,340	8,330	47,300
2/12/93	9.29	48,100	50	7,190	17,200	3,610	20,100	95,600
2/13/93	9.96	18,100	33	2,980	5,110	1,380	8,640	55,600
2/13/93	10.29	22,300	36	3,470	6,500	1,730	10,600	62,700
2/14/93	10.79	28,200	41	2,910	8,170	2,440	14,700	69,300
2/14/93	10.96	25,100	38	2,720	7,630	2,110	12,600	66,400
2/14/93	11.29	25,100	32	2,300	7,540	2,150	13,100	79,200
2/15/93	11.96	35,400	65	2,330	9,310	3,350	20,400	54,600
2/15/93	12.29	16,200	23	1,860	4,190	1,370	8,730	69,000
2/16/93	12.96	13,500	32	1,540	3,680	1,110	7,150	42,400
2/16/93	13.29	15,100	27	1,480	3,940	1,300	8,370	56,300
2/17/93	13.96	9,460	31	1,310	2,560	686	4,800	30,200
2/17/93	14.29	8,230	21	977	2,200	596	4,460	39,300
2/18/93	14.96	4,920	24	792	1,480	309	2,340	20,100
2/18/93	15.29	33,000	46	3,230	11,200	2,850	15,700	71,000
2/19/93	15.96	19,100	34	3,380	6,710	1,190	7,850	56,800
2/19/93	16.33	27,600	40	6,210	11,600	1,460	8,360	69,400
2/20/93	16.92	29,800	36	6,600	12,000	1,600	9,550	83,600
2/20/93	17.50	28,800	47	6,380	11,500	1,550	9,350	61,800
2/21/93	17.92	31,000	46	6,750	12,100	1,700	10,400	66,700

1,2-DCA µg/L	TCE µg/L	EDB µg/L
17	ND	ND
54	17	ND
37	ND	17
19	6.8	16
111	47	16
123	55	16
101	58	14
89	48	14
101	44	19
98	40	18
106	43	18
122	50	25
102	43	28
103	45	39
92	33	45
74	31	25
77	31	30
71	30	32
71	30	21
70	28	19
72	28	13
68	22	15
76	27	14
108	ND	36
52	15	ND
74	16	24
57	15	30
55	19	36
50	10	38
58	13	47
30	15	ND
38	13	ND
22	12	ND
27	16	ND
24	15	ND
ND	15	ND
72	17	22
54	18	15
107	18	11
120	19	34
101	17	34
110	18	39

Appendix C. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-SEPI (Continued)								
2/21/93	18.46	19,900	47	4,240	7,710	1,140	6,820	42,300
2/22/93	18.92	26,400	66	6,010	10,200	1,410	8,750	40,300
2/22/93	19.33	24,900	44	5,530	9,280	1,420	8,660	56,700
2/23/93	19.92	26,400	46	5,170	9,710	1,670	9,900	57,900
2/23/93	20.33	26,000	44	5,230	9,480	1,620	9,660	59,100
2/24/93	20.92	25,200	41	4,630	8,970	1,680	9,900	61,800
2/24/93	21.33	27,100	41	4,750	9,600	1,850	10,900	65,600
2/25/93	21.92	17,400	27	1,670	4,820	1,360	9,570	63,300
2/26/93	22.92	22,600	36	3,960	7,700	1,510	9,420	62,600
2/27/93	23.92	34,500	35	5,220	11,300	2,550	15,400	98,600
2/28/93	24.92	26,000	34	4,790	9,090	1,680	10,400	77,600
3/1/93	25.92	23,400	35	4,720	8,240	1,450	9,030	66,600
3/2/93	26.92	27,700	34	4,190	8,790	1,920	12,800	81,800
3/3/93	27.92	20,800	34	4,090	6,950	1,290	8,520	61,400
3/4/93	28.92	20,700	30	3,900	6,810	1,290	8,720	68,600
3/5/93	29.92	23,800	28	4,360	7,290	1,470	10,700	85,300
3/6/93	30.92	17,000	27	2,400	5,080	1,190	8,360	63,600
3/7/93	31.92	15,000	19	1,430	4,040	1,100	8,410	80,800
3/8/93	32.92	24,900	24	1,510	5,940	2,390	15,100	102,000
3/9/93	33.92	26,900	29	1,660	7,770	2,500	15,000	92,800
3/10/93	34.92	15,500	21	1,010	3,760	1,230	9,490	73,600
3/10/93	35.21	13,000	21	985	3,480	978	7,540	62,800
3/11/93	35.92	13,200	18	1,180	3,470	1,050	7,520	71,400
3/12/93	36.92	28,200	214	1,660	7,630	2,470	16,400	13,200
3/13/93	37.92	41,400	24	6,980	14,700	2,870	16,800	172,000
3/14/93	38.92	25,300	22	3,480	8,020	1,870	11,900	116,000
3/26/93	51.04	39,100	•	8,750	14,600	2,360	13,400	•
3/26/93	51.08	34,400	•	7,760	12,800	2,050	11,800	•
4/20/93	76.21	46,400	46	10,100	17,500	2,870	15,900	100,000
TFF-SEPE								
2/3/93	0.00	9,570	56	4,830	2,210	64	2,470	17,100
2/3/93	0.25	10,700	48	5,240	2,740	311	2,360	22,300
2/4/93	1.00	9,530	52	4,370	2,550	272	2,340	18,300
TFF-UVI								
2/3/93	0.00	9,810	59	4,930	2,280	168	2,430	16,700
2/3/93	0.25	10,800	•	5,330	2,790	336	2,390	•
2/4/93	1.00	9,570	59	4,370	2,570	294	2,340	16,300
2/4/93	1.25	9,380	47	4,380	2,440	188	2,370	20,100
2/5/93	1.96	10,600	55	4,440	3,030	221	2,890	19,300
2/5/93	2.29	11,100	67	4,480	3,180	222	3,230	16,500
2/6/93	2.96	11,800	54	4,540	3,460	360	3,490	21,900
2/6/93	3.29	11,100	54	4,310	3,220	239	3,340	20,700
2/7/93	3.96	17,000	47	4,810	5,670	546	5,950	36,000
2/7/93	4.29	16,700	52	4,820	5,770	419	5,690	32,300
2/8/93	4.96	29,200	48	5,710	10,300	1,580	11,600	60,600

1,2-DCA µg/L	TCE µg/L	EDB µg/L
45	17	ND
56	19	11
59	16	17
61	20	21
56	17	18
48	17	18
50	17	19
33	4.1	19
54	19	25
63	16	27
65	23	30
68	26	28
62	23	63
62	29	23
47	26	18
50	24	16
20	16	ND
19	8.7	15
19	11	ND
10	10	ND
14	5.5	ND
22	7.0	16
9.2	11	ND
26	7.5	20
122	8.5	30
56	14	21
10	ND	ND
ND	ND	ND
27	7.0	ND
112	42	15
122	49	15
103	49	15
91	43	12
103	47	15
83	46	13
89	44	13
119	51	20
99	37	20
106	42	19
96	36	19
103	45	29
78	32	29
93	32	44

Appendix C. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-UVI (Continued)								
2/8/93	5.25	42,900	53	5,970	15,200	2,820	18,900	81,600
2/9/93	5.96	29,200	48	5,710	10,300	1,580	11,600	60,400
2/9/93	6.29	33,600	55	6,030	12,000	1,800	13,800	60,900
2/10/93	6.96	27,200	56	4,820	9,470	1,220	11,700	48,700
2/10/93	7.29	20,600	45	3,700	6,400	231	10,300	45,500
2/11/93	7.96	21,500	41	3,730	6,710	679	10,400	52,000
2/11/93	8.29	25,100	42	3,700	8,360	1,400	11,600	59,400
2/12/93	8.96	18,200	41	3,360	5,520	982	8,370	44,800
2/12/93	9.29	46,100	52	7,110	17,000	2,990	19,000	88,800
2/13/93	9.96	22,300	35	3,060	6,190	1,650	11,400	63,200
2/13/93	10.29	33,600	44	4,000	10,700	2,550	16,300	77,000
2/14/93	10.79	29,000	40	2,920	8,790	2,320	15,000	72,800
2/14/93	10.96	30,200	41	2,900	9,490	2,370	15,400	74,400
2/14/93	11.29	26,000	38	2,230	7,740	2,100	13,900	68,700
2/15/93	11.96	27,400	36	2,010	7,580	2,360	15,500	75,200
2/15/93	12.29	17,400	31	1,590	4,520	1,350	9,970	56,200
2/16/93	12.96	16,400	30	1,450	4,110	1,130	9,760	54,400
2/16/93	13.29	14,600	•	1,250	3,510	945	8,940	•
2/17/93	13.96	10,600	•	921	1,990	279	7,430	•
2/17/93	14.29	8,040	•	700	1,500	203	5,640	•
2/18/93	14.96	4,460	•	342	292	8.7	3,820	•
2/18/93	15.29	22,800	•	2,330	7,230	1,060	12,200	•
2/19/93	15.96	17,400	•	3,000	6,060	829	7,470	•
2/19/93	16.33	24,900	•	5,140	9,460	964	9,340	•
2/20/93	16.92	26,100	•	5,720	10,200	1,200	8,980	•
2/20/93	17.50	26,600	•	5,840	10,200	1,180	9,390	•
2/21/93	17.92	26,800	•	5,900	10,300	1,220	9,360	•
2/21/93	18.46	17,400	•	3,660	5,990	392	7,400	•
2/22/93	18.92	23,400	•	5,240	8,560	811	8,830	•
2/22/93	19.33	19,700	•	4,630	6,850	300	7,910	•
2/23/93	19.92	23,200	•	4,640	8,370	1,090	9,130	•
2/23/93	20.33	22,300	•	4,620	7,720	670	9,250	•
2/24/93	20.92	22,400	•	4,290	7,900	1,010	9,250	•
2/24/93	21.33	23,900	•	4,350	8,460	1,170	9,930	•
2/25/93	21.92	17,300	•	1,820	4,920	800	9,730	•
2/26/93	22.92	20,500	•	3,560	6,890	1,070	8,970	•
2/27/93	23.92	28,600	•	4,570	9,530	1,550	12,900	•
2/28/93	24.92	22,600	•	4,230	7,760	986	9,670	•
3/1/93	25.92	21,200	•	4,120	7,200	942	8,980	•
3/2/93	26.92	20,400	•	3,710	6,670	905	9,080	•
3/3/93	27.92	19,200	•	3,610	6,200	803	8,580	•
3/4/93	28.92	17,700	•	3,500	5,720	716	7,760	•
3/5/93	29.92	18,200	•	4,180	5,710	606	7,660	•
3/6/93	30.92	19,000	•	2,380	5,440	1,020	10,200	•
3/7/93	31.92	12,200	•	1,310	3,400	721	6,780	•
3/8/93	32.92	17,400	•	1,100	4,240	1,350	10,700	•
3/9/93	33.92	33,200	•	2,220	10,500	2,740	17,700	•

1,2-DCA µg/L	TCE µg/L	EDB µg/L
76	32	50
75	32	31
75	29	39
69	29	26
60	24	15
61	24	14
65	19	18
72	26	14
100	ND	36
53	11	ND
68	10	33
61	13	41
55	13	52
39	ND	31
51	12	32
18	ND	ND
27	ND	10
14	ND	ND
27	11	ND
ND	10	ND
ND	12	ND
61	13	19
47	16	ND
97	20	27
108	18	34
103	17	34
89	15	31
40	13	ND
49	5.3	ND
54	14	18
51	14	18
52	14	18
48	14	18
49	14	19
30	5.5	23
52	16	25
59	13	25
61	19	28
68	21	18
61	20	27
63	24	27
44	20	17
46	23	15
19	11	ND
11	5.9	ND
15	8.0	ND
19	5.0	14

Appendix C. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX μg/L	BTEX % of TPH	Benzene μg/L	Toluene μg/L	Ethylbenzene μg/L	Total Xylenes μg/L	TPH* μg/L
TFF-UVI (Continued)								
3/10/93	34.92	12,900	•	1,040	3,430	826	7,600	•
3/10/93	35.21	11,000	•	907	2,910	581	6,560	•
3/11/93	35.92	15,500	•	1,080	3,900	1,110	9,440	•
3/12/93	36.92	19,400	•	1,310	5,170	1,400	11,500	•
3/13/93	37.92	36,200	•	5,040	12,500	2,190	16,500	•
3/14/93	38.92	26,900	•	3,250	8,260	1,690	13,700	•
3/26/93	51.04	34,500	•	7,860	12,600	1,960	12,100	•
3/26/93	51.08	30,500	•	6,910	11,100	1,720	10,800	•
4/20/93	76.21	35,700	•	8,630	13,700	1,890	11,500	•
TFF-UVO1								
2/3/93	0.00	2,710	120	1,460	615	60	577	2,250
2/3/93	0.25	3,220	88	1,680	821	100	621	3,640
2/4/93	1.00	2,740	89	1,320	734	89	600	3,080
2/5/93	1.96	3,300	95	1,470	957	79	789	3,490
2/6/93	2.96	5,990	110	2,370	1,760	200	1,660	5,460
2/7/93	3.96	9,580	40	2,720	3,180	385	3,290	23,800
2/8/93	4.96	20,800	72	4,050	7,420	1,120	8,250	28,800
2/9/93	5.96	25,400	40	4,690	9,010	1,530	10,200	62,800
TFF-UVO2								
2/3/93	0.00	1,230	•	661	274	27	271	•
2/3/93	0.25	668	118	360	164	20	124	564
2/4/93	1.00	825	102	408	214	26	177	806
2/5/93	1.96	1,750	255	768	489	44	446	685
2/6/93	2.96	2,470	111	1,010	733	86	637	2,220
2/7/93	3.96	6,060	74	1,760	2,050	240	2,010	8,230
2/8/93	4.96	14,300	61	2,740	5,080	776	5,750	23,400
2/9/93	5.96	21,200	38	4,050	7,670	1,290	8,240	55,500
3/10/93	35.21	7,600	•	596	2,050	440	4,510	•
TFF-UVO3								
2/3/93	0.00	124	210	74	27	2.0	21	59
2/3/93	0.25	571	275	309	141	17	104	208
2/4/93	1.00	338	109	172	88	11	67	311
2/5/93	1.96	622	212	286	173	15	148	294
2/6/93	2.96	623	99	286	174	15	148	632
2/7/93	3.96	4,270	64	1,240	1,440	177	1,410	6,700
2/8/93	4.96	10,300	47	1,950	3,670	565	4,140	21,700
2/9/93	5.96	19,200	45	3,710	7,000	1,170	7,360	43,000
TFF-UVO5								
2/3/93	0.00	19	43	11	3.9	0.3	3.5	44
2/3/93	0.25	174	191	97	43	4.2	30	91
2/4/93	1.00	49	54	24	13	1.7	10	91

1,2-DCA µg/L	TCE µg/L	EDB µg/L
12	7.1	ND
16	9.4	15
13	6.3	ND
22	9.1	15
117	9.9	33
50	9.1	23
14	ND	ND
ND	ND	ND
27	ND	ND
105	22	14
107	24	15
91	23	13
94	22	15
87	22	16
80	26	25
82	23	45
83	19	36
94	17	13
75	10	8.6
81	14	10
62	13	9.0
85	15	16
76	17	23
80	16	39
80	16	34
15	6.9	14
65	3.0	4.6
77	6.6	8.0
62	4.8	5.8
59	5.0	7.0
59	5.2	7.3
79	19	27
80	14	42
79	14	35
55	0.9	3.7
70	1.0	5.3
37	0.4	2.5

Appendix C. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-UVO5 (Continued)								
2/4/93	1.25	51	59	25	13	1.3	12	86
2/5/93	1.96	267	148	126	74	6.7	60	181
2/5/93	2.29	2,770	195	1,100	747	275	652	1,424
2/6/93	2.96	705	137	293	199	25	188	515
2/6/93	3.29	499	252	211	140	15	133	198
2/7/93	3.96	2,730	79	781	916	122	912	3,470
2/7/93	4.29	1,300	30	374	460	49	417	4,360
2/8/93	4.96	6,970	71	1,280	2,430	393	2,870	9,780
2/8/93	5.25	15,000	56	1,810	5,040	1,140	6,970	26,600
2/9/93	5.96	17,000	44	3,380	6,280	1,050	6,340	38,400
2/9/93	6.29	19,600	41	3,850	7,090	1,110	7,500	48,200
2/10/93	6.96	15,600	37	3,040	5,570	759	6,260	41,800
2/10/93	7.29	915	5	173	314	34	394	19,600
2/11/93	7.96	8,120	39	1,520	2,630	347	3,620	20,800
2/11/93	8.29	10,800	39	1,760	3,710	627	4,730	27,900
2/12/93	8.96	7,110	37	1,460	2,220	409	3,020	19,100
2/12/93	9.29	21,700	41	3,640	8,140	1,460	8,440	52,900
2/13/93	9.96	11,000	34	1,610	3,120	867	5,360	31,900
2/13/93	10.29	20,700	36	2,520	6,490	1,700	10,000	57,700
2/14/93	10.96	21,000	34	2,030	6,390	1,800	10,800	61,400
2/14/93	11.29	20,200	35	1,680	5,880	1,890	10,700	57,600
2/15/93	11.96	20,800	29	1,590	5,700	1,880	11,600	72,400
2/15/93	12.29	12,700	28	1,180	3,380	1,030	7,070	45,300
2/16/93	12.96	12,400	30	1,100	3,170	935	7,230	41,000
2/16/93	13.29	9,740	•	862	2,480	711	5,690	•
2/17/93	13.96	5,040	•	470	1,140	181	3,250	•
2/17/93	14.29	2,890	•	294	712	148	1,740	•
2/18/93	14.96	683	•	85	119	22	457	•
2/18/93	15.29	17,100	•	1,770	5,600	1,070	8,640	•
2/19/93	15.96	11,900	•	2,170	4,280	583	4,910	•
2/19/93	16.33	5,400	•	1,530	2,730	228	908	•
2/20/93	16.92	8,770	•	2,110	3,650	372	2,640	•
2/20/93	17.50	9,380	•	2,240	3,800	381	2,960	•
2/21/93	17.92	10,600	•	2,530	4,290	450	3,280	•
2/21/93	18.46	9,460	•	2,120	3,420	243	3,680	•
2/22/93	18.92	11,500	•	2,770	4,460	355	3,880	•
2/22/93	19.33	11,800	•	2,880	4,360	287	4,310	•
2/23/93	19.92	15,300	•	3,210	5,700	725	5,640	•
2/23/93	20.33	14,200	•	3,080	5,180	490	5,500	•
2/24/93	20.92	16,600	•	3,280	6,050	797	6,520	•
2/24/93	21.33	16,900	•	3,160	6,120	847	6,730	•
2/25/93	21.92	11,900	•	1,260	3,490	599	6,590	•
2/26/93	22.92	14,200	•	2,550	4,910	744	6,010	•
2/27/93	23.92	25,700	•	4,080	8,630	1,470	11,500	•
2/28/93	24.92	19,400	•	3,600	6,700	943	8,170	•
3/1/93	25.92	17,100	•	3,350	5,910	827	7,020	•
3/2/93	26.92	17,100	•	3,110	5,640	823	7,500	•

1,2-DCA µg/L	TCE µg/L	EDB µg/L
50	0.5	3.7
58	1.5	6.3
89	16	15
76	5.2	11
62	2.9	10
93	14	25
58	7.0	21
76	13	41
63	12	36
85	18	35
94	21	47
71	18	29
65	14	23
74	15	24
65	11	25
76	13	21
114	7.7	39
57	9.9	18
72	10	39
58	13	50
31	5.7	31
46	13	39
13	ND	ND
23	ND	10
ND	ND	ND
27	9.1	ND
23	6.5	ND
ND	ND	ND
59	9.8	12
45	12	ND
89	11	38
104	8.9	29
100	9.0	30
95	9.1	27
41	9.2	ND
52	9.8	11
55	9.0	19
49	10	18
57	11	18
47	12	18
50	11	19
34	3.9	21
52	12	23
60	12	26
61	16	28
66	17	30
57	16	27

Appendix C. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-UVO5 (Continued)								
3/3/93	27.92	15,000	•	2,790	4,900	719	6,600	•
3/4/93	28.92	13,600	•	2,700	4,470	615	5,840	•
3/5/93	29.92	13,600	•	3,210	4,370	499	5,510	•
3/6/93	30.92	15,800	•	1,950	4,530	898	8,460	•
3/7/93	31.92	9,090	•	931	2,520	560	5,080	•
3/8/93	32.92	12,700	•	779	3,150	1,010	7,760	•
3/9/93	33.92	28,200	•	1,870	9,050	2,360	14,900	•
3/10/93	34.92	11,100	•	722	2,590	833	6,980	•
3/10/93	35.21	6,230	•	481	1,710	349	3,690	•
3/11/93	35.92	11,100	•	725	2,770	809	6,810	•
3/12/93	36.92	15,000	•	940	3,920	1,160	8,940	•
3/13/93	37.92	28,400	•	4,060	10,200	1,820	12,300	•
3/14/93	38.92	22,300	•	2,580	7,050	1,570	11,100	•
3/26/93	51.04	26,000	•	6,090	9,650	1,460	8,830	•
3/26/93	51.08	23,600	•	5,500	8,710	1,320	8,120	•
4/20/93	76.21	28,100	•	6,920	10,900	1,490	8,780	•
4/21/93	77.25	26,200	•	5,500	10,300	1,500	8,920	•
TFF-EOO6-AQ								
2/3/93	0.00	ND	0	ND	ND	ND	ND	ND
2/3/93	0.25	0.4	3	0.4	ND	ND	ND	16
2/4/93	1.00	0.3	3	0.3	ND	ND	ND	12
2/4/93	1.25	0.6	0	0.3	0.3	ND	ND	ND
2/5/93	1.96	2.1	15	0.8	0.6	ND	0.7	14
2/5/93	2.29	8.8	22	3.1	2.5	0.3	2.9	40
2/6/93	2.96	4.5	7	1.2	1.3	0.2	1.8	66
2/6/93	3.29	2.2	10	0.7	0.7	ND	0.8	22
2/7/93	3.96	21	7	3.1	5.5	1.5	11	296
2/7/93	4.29	3.6	4	0.6	1.0	0.2	1.8	85
2/8/93	4.96	23	8	2.2	5.7	1.7	13	281
2/9/93	5.96	54	14	8.4	20	3.4	22	390
2/9/93	6.29	71	16	12	26	4.1	29	437
2/10/93	6.96	56	18	9.0	20	2.7	24	312
2/10/93	7.29	20	9	2.6	6.4	0.8	10	232
2/11/93	7.96	14	5	1.7	4.0	0.7	7.4	267
2/11/93	8.29	12	5	1.0	3.7	0.7	6.9	259
2/12/93	8.96	11	5	1.3	2.9	0.6	6.3	242
2/12/93	9.29	19	4	1.3	6.5	1.2	10	434
2/13/93	9.96	17	4	1.3	3.8	1.1	11	477
2/13/93	10.29	14	3	1.2	3.3	1.1	8.4	444
2/14/93	10.96	22	2	1.6	4.0	2.0	14	945
2/14/93	11.29	15	2	1.1	3.0	1.4	9.4	867
2/15/93	11.96	45	2	1.3	6.1	5.0	33	2,880
2/15/93	12.29	13	7	0.7	2.8	1.2	8.3	174
2/16/93	12.96	13	2	0.7	2.4	1.0	8.8	759
2/16/93	13.29	7.9	4	0.4	1.1	3.6	2.8	211
2/17/93	13.96	8.7	3	0.4	1.4	0.4	6.5	337
2/17/93	14.29	6.3	5	0.3	1.2	0.3	4.5	131

1,2-DCA µg/L	TCE µg/L	EDB µg/L
59	20	24
47	17	18
45	18	15
18	9.0	ND
16	6.5	ND
15	6.0	ND
19	ND	15
11	5.4	ND
15	6.1	14
12	ND	ND
19	6.5	18
114	8.5	32
52	7.7	23
12	ND	ND
ND	ND	ND
29	ND	ND
14	6.0	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
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ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND

Appendix C. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-EOO6-AQ (Continued)								
2/18/93	14.96	3.7	5	0.2	0.5	ND	3.0	80
2/18/93	15.29	25	8	0.6	7.1	1.0	16	297
2/19/93	15.96	3.6	4	0.4	1.1	0.2	1.9	95
2/22/93	19.33	8.7	•	0.9	3.3	0.3	4.2	•
2/23/93	20.33	5.5	•	0.6	2.2	0.3	2.4	•
2/24/93	20.92	2.7	•	0.4	0.8	0.2	1.3	•
2/24/93	21.33	2.9	•	0.4	0.9	0.2	1.4	•
2/25/93	21.92	3.6	•	0.3	0.7	0.3	2.3	•
2/26/93	22.92	2.8	•	0.4	0.7	0.2	1.5	•
2/27/93	23.92	5.2	•	0.6	1.1	0.4	3.1	•
2/28/93	24.92	5.0	•	0.6	1.1	0.4	2.9	•
3/1/93	25.92	1.8	•	0.4	0.6	0.2	0.6	•
3/2/93	26.92	2.3	•	0.5	0.8	0.2	0.8	•
3/3/93	27.92	1.8	•	0.4	0.6	0.2	0.6	•
3/4/93	28.92	1.8	•	0.4	0.6	0.2	0.6	•
3/5/93	29.92	1.8	•	0.4	0.6	0.2	0.6	•
3/6/93	30.92	3.7	•	0.6	1.0	0.3	1.8	•
3/7/93	31.92	4.0	•	0.4	0.7	0.3	2.6	•
3/8/93	32.92	3.4	•	0.3	0.5	0.3	2.3	•
3/9/93	33.92	19	•	0.5	2.3	1.4	15	•
3/10/93	34.92	4.6	•	0.3	0.9	0.3	3.1	•
3/10/93	35.21	4.9	•	0.3	0.9	0.3	3.4	•
3/11/93	35.92	5.2	•	ND	0.8	0.5	3.9	•
3/12/93	36.92	6.8	•	0.3	1.0	0.6	4.9	•
3/13/93	37.92	29	•	1.3	11	1.2	15	•
3/14/93	38.92	10	•	0.5	2.4	0.7	6.4	•
3/26/93	51.08	6.2	•	1.7	1.8	0.3	2.4	•
4/20/93	76.21	35	•	8.3	13	1.4	12	•
4/21/93	77.25	5.4	•	0.4	2.1	0.3	2.6	•
TFF-BT-1961								
2/20/93	16.92	668	•	160	277	24	207	•
2/20/93	17.04	84	•	19	35	1.7	28	•
2/21/93	17.92	30	•	6.3	13	0.7	10	•
TFF-BT-1962								
2/19/93	16.54	410	•	112	194	18	87	•
2/19/93	16.58	146	•	35	68	6.3	37	•
2/20/93	17.50	61	•	13	24	1.3	23	•
2/21/93	18.46	4.0	•	0.6	1.0	0.3	2.1	•

• Indicates analysis not performed.

ND: Not detected at or above limit of detection.

*Total Petroleum Hydrocarbons (Window: C6 to C12).

1,2-DCA µg/L	TCE µg/L	EDB µg/L
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
11	ND	2.1
2.6	ND	1.2
1.2	ND	1.0
6.6	ND	1.4
2.5	ND	0.9
1.6	ND	1.0
ND	ND	ND

Appendix D. DUS 1st Pass Vapor Data

Date Sampled	Elapsed Time Days	Total BTEX ppmv	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv	1,2-DCA ppmv	TCE ppmv	EDB ppmv
TFF-IOO6-VPR									
2/4/93	1.00	475	95	181	20	178	ND	ND	ND
2/10/93	8.04	306	16	76	16	197	ND	ND	ND
2/12/93	9.13	181	9.4	38	9	125	ND	ND	ND
2/14/93	11.04	2,090	101	666	183	1,140	ND	ND	ND
2/15/93	12.08	2,050	169	830	158	897	ND	ND	ND
2/18/93	14.08	955	85	314	76	480	ND	ND	ND
2/18/93	14.33	999	98	337	76	488	ND	ND	ND
2/18/93	15.04	392	64	122	15	191	ND	ND	ND
2/20/93	17.04	108	4.9	23	4.6	76	ND	ND	ND
2/21/93	18.08	82	3.0	13	2.8	63	ND	ND	ND
3/8/93	33.29	621	37	235	54	295	ND	ND	ND
3/10/93	35.13	762	49	299	59	356	ND	ND	ND
TFF-VESI									
2/3/93	0.04	461	87	169	16	189	ND	ND	ND
2/3/93	0.25	257	6.3	118	12	121	ND	ND	ND
2/4/93	0.50	586	138	240	24	184	ND	ND	ND
2/4/93	1.00	ND	ND	ND	ND	ND	ND	ND	ND
2/4/93	1.25	382	71	146	17	147	ND	ND	ND
2/5/93	1.50	432	82	145	20	185	ND	ND	ND
2/5/93	2.04	273	26	90	13	145	ND	ND	ND
2/6/93	3.13	232	18	78	12	124	ND	ND	ND
2/7/93	4.04	170	15	31	8.2	116	ND	ND	ND
2/8/93	5.10	377	41	145	22	170	ND	ND	ND
2/8/93	5.31	509	46	182	35	246	ND	ND	ND
2/8/93	5.46	340	22	108	22	188	ND	ND	ND
2/9/93	6.08	285	19	84	19	163	ND	ND	ND
2/9/93	6.38	301	58	100	15	128	ND	ND	ND
2/10/93	7.10	292	14	89	18	170	ND	ND	ND
2/10/93	7.29	213	16	66	13	118	ND	ND	ND
2/14/93	11.04	1,940	307	981	106	545	ND	ND	ND
2/15/93	12.08	1,390	102	579	110	598	ND	ND	ND
2/18/93	14.04	946	83	308	75	480	ND	ND	ND
2/18/93	15.04	291	48	84	11	147	ND	ND	ND
2/20/93	17.04	93	3.0	12	3.8	74	ND	ND	ND
2/21/93	18.08	97	4.8	22	4.1	66	ND	ND	ND
3/10/93	35.13	967	64	388	81	434	ND	ND	ND
TFF-GIW-816									
2/5/93	2.08	454	49	178	25	202	ND	ND	ND
2/15/93	12.04	1,560	118	671	124	644	ND	ND	ND
2/16/93	13.17	1,540	117	640	134	644	ND	ND	ND
TFF-GSW-016									
2/15/93	12.08	60	ND	8.2	ND	52	ND	ND	ND
2/16/93	13.17	119	ND	31	6.4	81	ND	ND	ND
TFF-GEW-808									
2/15/93	12.08	164	1.5	31	8.9	123	ND	ND	ND
2/16/93	13.17	412	22	110	26	254	ND	ND	ND

Appendix D. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX ppmv	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv	1,2-DCA ppmv	TCE ppmv	EDB ppmv
TFF-CFI									
2/3/93	0.08	ND	ND	ND	ND	ND	ND	ND	ND
2/3/93	0.25	ND	ND	ND	ND	ND	ND	ND	ND
3/2/93	26.29	ND	ND	ND	ND	ND	ND	ND	ND
3/10/93	35.25	4.4	ND	ND	ND	4.4	ND	ND	ND
3/12/93	37.10	4.8	ND	1.1	ND	3.7	ND	ND	ND
TFF-CFO									
2/3/93	0.08	ND	ND	ND	ND	ND	ND	ND	ND
2/3/93	0.25	ND	ND	ND	ND	ND	ND	ND	ND
3/2/93	26.29	ND	ND	ND	ND	ND	ND	ND	ND
3/10/93	35.25	ND	ND	ND	ND	ND	ND	ND	ND
3/12/93	37.10	ND	ND	ND	ND	ND	ND	ND	ND
TFF-EOO6-VPR									
2/3/93	0.04	1.8	1.8	ND	ND	ND	ND	ND	ND
2/3/93	0.25	ND	ND	ND	ND	ND	ND	ND	ND
2/4/93	0.50	ND	ND	ND	ND	ND	ND	ND	ND
2/4/93	1.00	ND	ND	ND	ND	ND	ND	ND	ND
2/5/93	2.00	ND	ND	ND	ND	ND	ND	ND	ND
2/6/93	3.13	ND	ND	ND	ND	ND	ND	ND	ND
2/7/93	4.04	ND	ND	ND	ND	ND	ND	ND	ND
2/8/93	5.46	ND	ND	ND	ND	ND	ND	ND	ND
2/9/93	6.13	ND	ND	ND	ND	ND	ND	ND	ND
2/14/93	11.04	137	95	42	ND	ND	ND	ND	ND
2/15/93	12.08	ND	ND	ND	ND	ND	ND	ND	ND
3/8/93	33.29	99	61	38	ND	ND	ND	ND	ND
3/10/93	35.13	52	7.0	34	ND	12	ND	ND	ND

ND: Not detected at or above limit of detection.

Appendix E. DUS 2nd Pass Aqueous Data

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-MEGA-AQ								
5/28/93	5.29	37,800	27	6,390	16,400	1,930	13,100	142,000
5/29/93	6.04	40,400	27	5,900	17,100	2,240	15,200	152,000
5/30/93	7.04	52,100	34	6,740	21,700	3,020	20,600	154,000
5/31/93	8.08	31,500	23	3,540	12,500	1,970	13,500	136,000
6/1/93	9.25	44,800	30	9,800	14,900	1,750	18,400	151,000
6/2/93	10.13	42,100	29	3,720	14,900	3,080	20,400	145,000
6/3/93	11.38	41,100	30	3,250	14,200	3,080	20,600	139,000
6/4/93	11.88	41,200	29	3,060	13,800	3,160	21,200	141,000
6/5/93	12.88	36,000	30	1,940	10,600	2,930	20,500	122,000
6/6/93	13.88	34,700	24	1,630	9,570	2,830	20,700	142,000
6/7/93	14.88	31,600	29	1,340	8,240	2,590	19,400	110,000
6/8/93	15.88	29,000	28	1,360	7,480	2,350	17,800	102,000
6/9/93	16.88	29,900	41	1,680	8,130	2,370	17,700	72,600
6/10/93	17.88	31,200	41	1,950	8,780	2,450	18,000	76,800
6/11/93	18.88	33,800	39	2,190	10,100	2,680	18,800	85,700
6/12/93	19.88	36,000	38	2,070	11,400	2,890	19,600	93,700
6/13/93	20.88	33,700	35	2,760	12,600	3,050	15,300	96,900
6/14/93	21.88	37,400	38	3,550	15,200	3,540	15,100	97,200
6/15/93	22.96	32,100	33	3,100	13,100	2,980	12,900	97,600
6/16/93	23.88	39,000	41	3,400	13,300	2,950	19,400	94,400
6/17/93	24.88	35,100	40	3,090	11,900	2,610	17,500	87,300
6/18/93	25.88	37,700	45	3,420	12,900	2,800	18,600	84,700
6/20/93	27.88	33,300	40	2,470	10,800	2,720	17,300	82,800
6/21/93	28.88	28,200	35	1,980	8,830	2,330	15,100	80,800
6/23/93	30.88	42,200	44	4,890	14,400	3,330	19,600	96,000
6/25/93	32.88	42,900	44	4,910	14,800	3,300	19,900	97,400
6/27/93	34.88	36,900	41	3,680	12,600	2,910	17,700	89,300
6/28/93	35.88	35,700	39	3,560	12,100	2,850	17,200	90,500
6/30/93	37.88	31,200	39	2,800	10,400	2,500	15,500	79,900
7/2/93	39.88	31,400	40	2,950	9,810	2,610	16,000	79,400
7/4/93	41.88	40,100	43	4,830	14,000	3,070	18,200	93,800
7/5/93	42.88	37,000	40	4,260	13,500	2,740	16,500	92,500
7/7/93	44.88	33,900	38	3,080	12,300	2,710	15,800	89,400
7/9/93	46.88	28,300	36	2,190	9,430	2,380	14,300	78,300
TFF-SEPI								
5/28/93	5.29	32,800	43	6,090	12,300	2,150	12,300	76,700
5/29/93	6.04	27,300	49	5,080	9,750	1,890	10,600	56,100
5/30/93	7.04	22,600	47	4,130	7,800	1,600	9,090	47,700
5/31/93	8.08	22,200	41	4,000	7,260	1,640	9,350	54,700
6/1/93	9.25	15,300	38	2,710	5,160	1,110	6,290	40,300
6/2/93	10.13	16,900	47	2,500	7,460	1,070	5,910	35,800
6/3/93	11.38	13,100	40	2,140	4,250	1,020	5,670	33,000
6/4/93	11.88	13,500	41	2,140	4,280	1,050	6,060	33,300
6/5/93	12.88	11,700	35	1,820	3,690	918	5,280	33,700
6/6/93	13.88	11,200	36	1,800	3,600	815	4,980	30,800
6/7/93	14.88	9,110	37	1,590	3,020	641	3,860	24,300
6/8/93	15.88	13,700	38	2,520	4,750	933	5,470	36,400
6/9/93	16.88	15,300	39	2,850	5,590	1,000	5,870	38,900
6/10/93	17.88	15,700	46	3,150	5,690	1,000	5,900	34,300
6/11/93	18.88	15,800	44	3,530	5,630	961	5,720	36,000

1,2-DCA µg/L	TCE µg/L	EDB µg/L	Surrogate** % Recovery
188	ND	44	92
151	ND	43	86
110	13	43	86
80	7.8	37	92
50	11	39	118
37	11	36	130
22	ND	26	122
ND	ND	24	134
ND	7.3	17	60
ND	ND	8.8	102
ND	ND	6.0	91
ND	ND	6.7	70
ND	ND	17	91
ND	ND	11	92
ND	ND	ND	82
ND	ND	27	82
24	18	28	83
40	19	33	102
31	16	29	99
ND	17	ND	112
ND	14	ND	110
ND	16	ND	110
ND	ND	ND	•
ND	ND	ND	•
50	ND	37	•
48	ND	37	93
25	ND	ND	123
25	ND	ND	124
ND	ND	ND	84
ND	ND	ND	90
27	ND	ND	90
ND	ND	ND	86
ND	ND	ND	84
ND	ND	ND	80
ND	62	ND	86
ND	60	ND	92
ND	56	ND	76
ND	42	ND	90
ND	43	ND	83
ND	43	ND	80
ND	24	ND	98
ND	23	ND	95
ND	42	ND	84
ND	28	ND	72
ND	39	ND	72
ND	20	ND	•
ND	20	ND	70
ND	21	ND	90
ND	23	ND	90

Appendix E. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-SEPI (Continued)								
6/12/93	19.88	18,200	44	3,680	6,290	1,170	7,080	41,200
6/13/93	20.88	4,490	38	1,140	1,740	280	1,330	11,900
6/14/93	21.88	12,400	38	3,350	5,070	830	3,100	32,300
6/15/93	22.96	10,600	41	2,820	4,360	720	2,650	25,800
6/15/93	23.08	11,800	44	2,800	4,350	702	3,960	26,900
6/16/93	23.88	12,000	49	2,660	4,190	759	4,350	24,400
6/17/93	24.88	10,300	44	2,210	3,970	106	4,010	23,300
6/18/93	25.88	11,100	50	2,100	4,030	745	4,240	22,000
6/19/93	26.88	9,810	37	1,780	3,680	650	3,700	26,300
6/20/93	27.88	9,430	45	1,610	3,800	587	3,430	21,100
6/21/93	28.88	10,800	58	1,660	4,020	741	4,340	18,600
6/21/93	29.21	6,330	45	1,100	2,350	431	2,450	14,100
6/22/93	29.88	8,180	50	1,460	2,970	548	3,200	16,200
6/22/93	30.25	8,430	•	1,390	3,110	568	3,360	•
6/23/93	30.88	8,280	46	1,270	2,920	593	3,500	17,900
6/24/93	31.88	8,290	52	1,530	3,100	542	3,120	16,000
6/25/93	32.88	9,060	58	1,730	3,200	616	3,510	15,700
6/26/93	33.88	7,730	61	1,700	2,670	506	2,850	12,700
6/27/93	34.88	6,780	56	1,890	2,510	358	2,020	12,100
6/28/93	35.88	6,830	53	1,790	2,570	369	2,100	13,000
6/29/93	36.88	6,580	53	1,460	2,460	392	2,270	12,400
6/30/93	37.88	6,870	52	1,360	2,470	447	2,590	13,200
7/1/93	38.88	7,020	45	1,250	2,530	477	2,760	15,500
7/2/93	39.88	10,200	54	1,720	3,930	689	3,910	19,000
7/3/93	40.88	8,740	55	1,600	3,390	565	3,190	15,900
7/4/93	41.88	8,280	52	1,500	3,200	541	3,040	16,000
7/5/93	42.88	7,810	53	1,400	3,030	512	2,870	14,800
7/6/93	43.88	8,460	54	1,470	3,300	559	3,130	15,600
7/7/93	44.88	8,650	53	1,440	3,320	590	3,300	16,200
7/8/93	45.88	8,500	50	1,390	3,280	581	3,250	16,900
7/9/93	46.88	8,690	55	1,400	3,370	594	3,330	15,900
7/12/93	50.08	12,800	57	2,080	5,290	821	4,590	22,300
7/16/93	54.04	7,560	50	1,150	2,990	521	2,900	15,200
7/19/93	57.25	8,080	52	1,270	3,160	558	3,090	15,600
7/22/93	60.21	7,070	48	1,050	2,730	508	2,780	14,600
7/29/93	67.08	10,200	53	1,520	4,020	722	3,950	19,100
8/3/93	72.08	9,170	50	1,250	3,430	684	3,810	18,400
8/5/93	74.08	8,860	50	1,180	3,300	661	3,720	17,600
9/13/93	113.22	8,650	43	1,150	3,410	590	3,500	20,200
TFF-UVI								
5/23/93	0.00	32,000	44	5,850	11,800	2,030	12,300	72,000
5/28/93	5.29	34,200	46	5,890	12,500	2,130	13,700	74,200
5/29/93	6.04	25,900	44	4,710	9,030	1,580	10,600	59,200
5/30/93	7.04	19,500	45	3,690	6,550	696	8,580	43,800
5/31/93	8.08	20,800	45	3,900	6,610	1,050	9,280	46,100
6/1/93	9.25	14,900	44	2,420	6,030	301	6,100	34,000
6/2/93	10.13	12,000	41	2,300	3,620	229	5,850	29,500
6/3/93	11.38	11,500	45	2,000	3,520	446	5,540	25,400
6/4/93	11.88	11,900	41	2,880	2,960	247	5,800	29,000
6/5/93	12.88	10,300	38	1,680	3,010	398	5,260	27,400
6/6/93	13.88	10,600	42	2,630	2,750	305	4,870	25,500
6/7/93	14.88	6,620	36	1,210	1,610	30	3,770	18,300

1,2-DCA µg/L	TCE µg/L	EDB µg/L	Surrogate** % Recovery
ND	25	ND	86
ND	17	ND	112
ND	36	ND	92
ND	40	ND	92
ND	22	ND	102
ND	22	ND	102
ND	24	ND	103
ND	26	ND	105
ND	25	ND	108
ND	28	ND	•
ND	28	ND	•
ND	33	ND	•
ND	19	ND	•
ND	18	ND	•
ND	16	ND	•
ND	21	ND	•
ND	27	ND	92
ND	30	ND	94
ND	30	ND	92
ND	28	ND	93
ND	27	ND	91
ND	24	ND	92
ND	24	ND	92
ND	26	ND	94
ND	28	ND	94
ND	29	ND	95
ND	29	ND	95
ND	33	ND	94
ND	32	ND	97
ND	28	ND	90
ND	31	ND	90
ND	41	ND	92
ND	49	ND	94
ND	53	ND	99
ND	50	ND	106
ND	66	ND	104
ND	52	ND	104
ND	44	ND	104
ND	71	ND	•
ND	48	ND	84
ND	46	ND	84
ND	46	ND	94
ND	40	ND	82
ND	31	ND	98
ND	31	ND	65
ND	32	ND	81
ND	38	ND	108
ND	16	ND	97
ND	34	ND	83
ND	22	ND	76
ND	31	ND	64

Appendix E. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-UVI (Continued)								
6/8/93	15.88	11,300	38	2,310	3,620	252	5,150	29,700
6/9/93	16.88	13,800	49	2,810	4,840	324	5,790	28,100
6/10/93	17.88	12,700	48	2,780	4,350	88	5,500	26,700
6/11/93	18.88	13,200	46	3,120	4,470	145	5,450	28,500
6/12/93	19.88	16,500	46	3,500	5,560	286	7,140	36,000
6/13/93	20.88	4,100	31	987	1,110	79	1,920	13,400
6/14/93	21.88	11,300	44	3,070	4,590	649	2,970	25,900
6/15/93	22.96	9,510	42	2,590	3,940	402	2,580	22,900
6/16/93	23.88	7,640	44	2,040	2,040	ND	3,560	17,500
6/17/93	24.88	7,500	45	1,780	2,460	13	3,250	16,600
6/18/93	25.88	7,470	44	1,640	2,540	7.4	3,280	16,900
6/19/93	26.88	7,520	46	1,540	2,840	71	3,070	16,300
6/20/93	27.88	7,850	44	1,460	3,010	66	3,310	18,000
6/21/93	28.88	6,240	36	1,080	2,150	24	2,990	17,300
6/22/93	29.88	5,980	44	1,210	1,770	3.0	3,000	13,700
6/22/93	30.25	7,090	•	1,210	2,570	263	3,050	•
6/23/93	30.88	7,320	47	1,300	2,520	53	3,450	15,700
6/23/93	31.13	7,280	•	1,240	2,620	336	3,080	•
6/24/93	31.88	7,250	51	1,360	2,640	306	2,940	14,200
6/25/93	32.88	7,760	56	1,740	2,740	326	2,950	13,900
6/26/93	33.88	6,080	55	1,470	2,050	247	2,310	11,100
6/27/93	34.88	6,010	54	1,620	2,090	224	2,080	11,100
6/28/93	35.88	6,240	51	1,560	2,190	261	2,230	12,200
6/29/93	36.88	5,690	50	1,260	1,960	252	2,220	11,400
6/30/93	37.88	5,750	49	1,110	1,970	260	2,410	11,800
7/1/93	38.88	6,740	47	1,100	2,300	345	3,000	14,200
7/2/93	39.88	8,780	51	1,520	3,250	425	3,590	17,300
7/3/93	40.88	7,320	53	1,390	2,600	311	3,020	13,900
7/4/93	41.88	7,260	52	1,320	2,580	315	3,040	13,900
7/5/93	42.88	6,920	52	1,280	2,470	285	2,880	13,300
7/6/93	43.88	7,240	53	1,330	2,550	297	3,060	13,700
7/7/93	44.88	7,760	48	1,290	2,700	345	3,430	16,200
7/8/93	45.88	7,020	50	1,210	2,280	75	3,460	14,000
7/9/93	46.88	6,650	49	1,120	1,960	41	3,530	13,500
7/12/93	50.08	12,300	55	2,060	5,060	704	4,440	22,200
7/16/93	54.04	6,830	51	1,070	2,740	404	2,620	13,300
7/19/93	57.25	6,570	53	1,090	2,620	308	2,550	12,400
7/22/93	60.21	5,460	47	877	1,960	228	2,390	11,600
7/29/93	67.08	9,040	51	1,380	3,570	522	3,570	17,900
8/3/93	72.08	8,220	51	1,140	3,120	549	3,410	16,100
8/5/93	74.08	8,080	52	1,110	3,050	489	3,430	15,600
9/13/93	113.22	7,630	44	1,100	2,930	398	3,200	17,200
9/22/93	122.22	6,840	43	904	2,680	488	2,770	15,900
TFF-UVO5								
5/23/93	0.00	34,100	47	6,220	12,500	2,190	13,200	73,000
5/28/93	5.29	10,200	•	1,920	3,790	635	3,880	•
5/29/93	6.04	2,190	•	451	787	131	817	•
5/30/93	7.04	10,300	•	2,060	3,530	496	4,170	•
5/31/93	8.08	16,800	•	3,120	5,410	887	7,370	•
6/3/93	11.38	1,930	•	393	621	100	819	•
6/7/93	14.88	62	•	7.6	30	0.9	23	•
6/9/93	16.88	4,820	•	1,060	1,760	168	1,830	•

1,2-DCA µg/L	TCE µg/L	EDB µg/L	Surrogate** % Recovery
ND	16	ND	•
ND	19	ND	82
ND	18	ND	82
ND	18	ND	88
ND	20	ND	90
ND	18	ND	89
ND	27	ND	91
ND	32	ND	95
ND	17	ND	86
ND	13	ND	104
ND	13	ND	93
ND	21	ND	52
ND	26	ND	•
ND	14	ND	•
ND	15	ND	•
ND	12	ND	•
ND	14	ND	•
ND	13	ND	101
ND	15	ND	•
ND	21	ND	96
ND	22	ND	94
ND	22	ND	93
ND	21	ND	93
ND	21	ND	92
ND	15	ND	93
ND	21	ND	93
ND	18	ND	95
ND	23	ND	96
ND	21	ND	93
ND	23	ND	92
ND	27	ND	96
ND	23	ND	92
ND	19	ND	90
ND	22	ND	95
ND	32	ND	90
ND	36	ND	96
ND	42	ND	100
ND	38	ND	100
ND	52	ND	105
ND	38	ND	106
ND	36	ND	109
ND	51	ND	•
ND	39	ND	120
ND	52	ND	87
ND	22	ND	95
ND	7.5	ND	99
ND	26	ND	58
ND	26	ND	98
ND	ND	ND	106
ND	ND	ND	90
ND	6.1	ND	•

Appendix E. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-UVO5 (Continued)								
6/10/93	17.88	4,500	•	1,110	1,600	53	1,740	•
6/14/93	21.88	3,360	•	1,030	1,340	207	782	•
6/19/93	24.88	1,180	•	354	398	18	415	•
6/21/93	28.88	2,170	•	417	803	66	882	•
6/23/93	30.88	961	•	197	384	47	333	•
6/23/93	31.13	233	•	51	84	12	86	•
6/24/93	31.88	228	•	59	81	11	77	•
6/28/93	35.88	99	•	30	32	4.8	32	•
6/30/93	37.88	148	•	19	24	13	92	•
7/1/93	38.88	380	•	74	127	22	157	•
7/5/93	42.88	81	•	22	30	3.6	25	•
7/7/93	44.88	220	•	48	80	11	81	•
7/8/93	45.88	127	•	34	43	2.6	47	•
7/12/93	50.08	864	•	175	373	52	264	•
7/16/93	54.04	160	•	36	71	7.8	45	•
7/19/93	57.25	105	•	29	49	2.9	24	•
7/22/93	60.21	13	•	1.9	7.1	0.8	3.4	•
7/29/93	67.08	541	•	108	219	32	182	•
8/3/93	72.08	314	•	60	127	20	107	•
8/5/93	74.08	285	•	53	114	17	101	•
9/15/93	115.06	79	•	9.4	49	3.4	17	•
9/22/93	122.22	203	55	29.0	78	19.0	77	370
TFF-EOO6-AQ								
5/28/93	5.29	12	•	2.1	2.6	2.0	5.2	•
5/29/93	6.08	5.3	•	1.2	1.2	0.8	2.1	•
5/30/93	7.04	8.5	•	1.9	2.5	0.6	3.5	•
5/31/93	8.08	5.0	•	1.5	1.3	0.4	1.8	•
6/2/93	10.13	4.9	•	1.1	1.2	0.6	2.0	•
6/3/93	11.38	4.0	•	0.9	1.0	0.5	1.6	•
6/4/93	11.88	4.0	•	1.0	1.1	ND	1.9	•
6/6/93	13.88	8.4	•	0.5	2.4	0.9	4.6	•
6/7/93	14.88	1.0	•	0.2	0.3	ND	0.5	•
6/9/93	16.88	8.0	•	1.7	2.5	0.8	3.0	•
6/10/93	17.88	5.5	•	1.2	1.9	ND	2.4	•
6/11/93	18.88	6.2	•	0.6	2.2	0.6	2.8	•
6/13/93	20.88	2.5	•	0.7	0.6	ND	1.2	•
6/14/93	21.88	2.0	•	0.6	0.6	ND	0.8	•
6/15/93	23.88	6.9	•	1.1	2.7	ND	3.1	•
6/17/93	24.88	3.5	•	0.7	1.3	ND	1.5	•
6/18/93	25.88	3.3	•	0.5	1.4	ND	1.4	•
6/20/93	27.88	4.2	•	0.6	1.7	ND	1.9	•
6/21/93	28.88	3.9	•	0.6	1.3	0.2	1.8	•
6/23/93	30.88	2.7	•	0.4	1.0	0.2	1.1	•
6/24/93	31.88	ND	•	ND	ND	ND	ND	•
6/25/93	32.88	ND	•	ND	ND	ND	ND	•
6/27/93	34.88	ND	•	ND	ND	ND	ND	•
6/28/93	35.88	ND	•	ND	ND	ND	ND	•
6/30/93	37.88	ND	•	ND	ND	ND	ND	•
7/1/93	38.88	ND	•	ND	ND	ND	ND	•
7/2/93	39.88	0.5	•	0.2	0.3	ND	ND	•
7/7/93	44.88	ND	•	ND	ND	ND	ND	•
7/8/93	45.88	ND	•	ND	ND	ND	ND	•

1,2-DCA µg/L	TCE µg/L	EDB µg/L	Surrogate** % Recovery
ND	7.3	ND	•
ND	9.9	ND	89
ND	17	ND	104
ND	13	ND	102
ND	6.5	ND	101
ND	ND	ND	101
ND	4.2	ND	92
ND	ND	ND	95
ND	ND	ND	108
ND	5.4	ND	96
ND	ND	ND	94
ND	ND	ND	93
ND	ND	ND	97
ND	ND	ND	92
4.1	4.5	0.4	82
4.9	3.7	ND	82
2.4	ND	ND	119
4.0	12	ND	112
2.5	6.5	ND	114
2.9	5.9	ND	114
1.0	5.3	ND	93
ND	ND	ND	116
ND	ND	ND	102
ND	ND	ND	108
ND	ND	ND	•
ND	0.5	ND	•
ND	ND	ND	99
ND	ND	ND	129
ND	ND	ND	106
ND	ND	ND	94
ND	ND	ND	108
ND	ND	ND	104
ND	ND	ND	109
ND	ND	ND	107
ND	ND	ND	107
ND	ND	ND	110
ND	ND	ND	102
ND	ND	ND	103
ND	ND	ND	102
ND	ND	ND	102
ND	ND	ND	99
ND	ND	ND	102
ND	ND	ND	99
ND	ND	ND	98
ND	ND	ND	94
ND	ND	ND	100
ND	ND	ND	99
ND	ND	ND	98
ND	ND	ND	84
ND	ND	ND	99
ND	ND	ND	101

Appendix E. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
TFF-EOO6-AQ (Continued)								
7/9/93	46.88	ND	•	ND	ND	ND	ND	•
7/12/93	50.08	0.4	•	0.2	0.2	ND	ND	•
7/16/93	54.04	0.3	•	0.3	ND	ND	ND	•
7/19/93	57.25	0.5	•	0.2	0.3	ND	ND	•
7/22/93	60.21	ND	•	ND	ND	ND	ND	•
7/29/93	67.08	ND	•	ND	ND	ND	ND	•
8/3/93	72.08	ND	•	ND	ND	ND	ND	•
8/5/93	74.08	1.5	•	0.3	0.2	0.3	0.7	•
9/13/93	113.22	38	•	0.4	2.9	4.2	30	•
TFF-TNK2-BOT								
6/2/93	10.25	8,390	50	2,000	2,430	360	3,600	16,800
6/14/93	22.08	8,430	45	2,540	3,440	157	2,290	18,900
TFF-TNK3-BOT								
6/1/93	9.04	10,000	48	2,530	3,040	372	4,060	20,900
6/6/93	14.46	5,670	44	1,190	1,200	61	3,220	13,000
6/8/93	16.50	5,650	41	1,090	1,010	51	3,500	13,900
6/10/93	18.13	7,840	53	2,040	2,420	85	3,300	14,800
6/11/93	19.08	9,240	56	2,490	2,950	65	3,740	16,400
6/12/93	20.33	9,200	49	2,670	3,620	273	2,640	18,800
6/14/93	22.08	1,010	27	190	94	7.6	717	3,680
6/15/93	23.13	568	5	393	150	4.1	21	12,600
6/15/93	23.33	5,980	49	2,010	2,140	26	1,800	12,100
6/16/93	24.08	5,920	55	2,080	1,820	0.8	2,020	10,800
6/21/93	29.25	1,520	29	616	675	2.6	228	5,290
6/22/93	30.25	2,570	42	662	1,080	39	789	6,130

Note: • Indicates analysis not performed.

ND: Not detected at or above limit of detection.

*Total Petroleum Hydrocarbons (Window: C6 to C12).

**Chlorobenzene (QC Limits: 50 to 150).

1,2-DCA µg/L	TCE µg/L	EDB µg/L	Surrogate** % Recovery
ND	ND	ND	102
ND	ND	ND	94
ND	ND	ND	87
ND	ND	ND	87
ND	ND	ND	116
ND	ND	ND	111
ND	ND	ND	114
ND	ND	ND	108
ND	ND	ND	*
ND	24	ND	100
ND	15	ND	100
ND	25	ND	94
ND	25	ND	70
ND	17	ND	82
ND	12	ND	87
ND	13	ND	80
ND	29	ND	80
ND	ND	ND	84
ND	ND	ND	*
ND	5.9	ND	103
ND	7.4	ND	97
ND	12	ND	*
ND	12	ND	*

Appendix F. DUS 2nd Pass Vapor Data

Date Sampled	Elapsed Time Days	Total BTEX ppmv	BTEX % of TPH	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv	TPH* mg/L air	TPH* ppmv	HC** mg/L air	HC** ppmv
*TFF-IOO6-VPR****											
5/27/93	4.17	•	•	•	•	•	•	91	25,800	116	33,000
6/1/93	9.13	1,540	10	217	579	121	621	57	16,100	63	18,000
6/3/93	11.21	1,790	14	152	538	170	929	44	12,500	48	13,600
6/7/93	15.21	•	•	•	•	•	•	21	6,010	26	7,240
6/10/93	18.08	•	•	•	•	•	•	41	11,600	48	13,600
6/14/93	22.00	•	•	•	•	•	•	93	26,500	100	28,500
6/17/93	25.00	•	•	•	•	•	•	136	38,700	148	42,100
6/21/93	29.00	•	•	•	•	•	•	86	24,500	83	23,600
6/24/93	32.00	•	•	•	•	•	•	124	35,300	120	34,000
6/28/93	36.00	•	•	•	•	•	•	72	20,300	71	20,100
7/1/93	39.00	•	•	•	•	•	•	27	7,790	30	8,550
TFF-ICE-IN											
5/24/93	1.33	•	•	•	•	•	•	120	34,100	211	59,800
5/24/93	1.63	•	•	•	•	•	•	143	40,700	305	86,600
5/25/93	2.04	3,680	11	172	2,170	207	1,130	120	34,200	239	67,700
5/25/93	2.38	3,150	8	123	1,740	205	1,080	147	41,800	237	67,400
5/26/93	3.08	•	•	•	•	•	•	51	14,600	95	27,100
5/26/93	3.29	5,190	18	145	2,780	371	1,890	100	28,500	164	46,600
5/27/93	4.08	4,540	19	114	2,270	322	1,830	83	23,700	120	34,200
5/27/93	4.29	•	•	•	•	•	•	70	19,900	102	29,000
5/28/93	5.00	5,960	47	667	2,470	429	2,390	45	12,800	64	18,300
5/28/93	5.29	•	•	•	•	•	•	32	9,200	39	11,200
5/29/93	6.00	•	•	•	•	•	•	33	9,330	39	11,200
5/30/93	7.00	•	•	•	•	•	•	72	20,300	87	24,600
5/31/93	8.04	4,680	20	577	1,670	387	2,050	83	23,700	104	29,500
6/1/93	9.13	1,200	10	208	573	103	513	43	12,200	49	14,000
6/1/93	9.25	•	•	•	•	•	•	43	12,300	51	14,600
6/2/93	10.08	1,340	10	182	505	107	543	46	13,000	53	15,000
6/2/93	10.33	•	•	•	•	•	•	48	13,700	55	15,700
6/3/93	11.00	1,640	13	145	530	141	821	43	12,300	47	13,200
6/3/93	11.25	1,820	16	172	597	172	877	40	11,400	45	12,800
6/4/93	12.00	1,630	21	125	502	156	844	27	7,610	29	8,280
6/4/93	12.21	•	•	•	•	•	•	22	6,320	23	6,670
6/5/93	13.00	•	•	•	•	•	•	27	7,540	28	7,820
6/6/93	14.08	•	•	•	•	•	•	30	8,610	32	9,090
6/7/93	14.96	1,440	23	85	496	141	713	23	6,400	24	6,930
6/7/93	15.25	948	17	112	342	83	411	20	5,600	24	6,930
6/8/93	15.96	1,230	16	163	548	100	416	28	7,840	33	9,430
6/8/93	16.25	•	•	•	•	•	•	31	8,740	37	10,500
6/9/93	17.00	1,440	21	182	671	113	475	24	6,870	30	8,470
6/9/93	17.29	•	•	•	•	•	•	38	10,800	45	12,900
6/10/93	18.00	2,130	22	54	1,150	188	740	35	9,880	42	11,800
6/10/93	18.25	•	•	•	•	•	•	38	10,700	44	12,500
6/11/93	19.00	910	11	140	504	58	208	29	8,330	35	9,900
6/11/93	19.25	•	•	•	•	•	•	35	9,990	40	11,400
6/12/93	19.96	•	•	•	•	•	•	32	9,130	36	10,300
6/13/93	21.00	•	•	•	•	•	•	41	11,500	46	13,000
6/14/93	22.00	1,540	14	236	811	109	381	38	10,900	44	12,600
6/14/93	22.25	•	•	•	•	•	•	50	14,100	57	16,200
6/15/93	23.00	1,980	16	315	1,020	143	500	44	12,400	51	14,600
6/15/93	23.25	•	•	•	•	•	•	53	15,000	61	17,200
6/16/93	24.00	917	7	162	459	64	232	44	12,500	52	14,900
6/16/93	24.25	•	•	•	•	•	•	47	13,200	54	15,400
6/17/93	25.00	1,040	9	190	511	72	272	41	11,500	49	13,800
6/17/93	25.25	•	•	•	•	•	•	41	11,500	49	13,800
6/18/93	26.00	1,300	14	197	633	100	365	33	9,300	38	10,800

Appendix F. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX ppmv	BTEX % of TPH	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv	TPH* mg/L air	TPH* ppmv	HC** mg/L air	HC** ppmv
TFF-ICE-IN (Continued)											
6/18/93	26.21	•	•	•	•	•	•	33	9,500	38	10,900
6/19/93	27.00	•	•	•	•	•	•	24	6,900	27	7,700
6/20/93	28.00	•	•	•	•	•	•	17	4,800	18	5,040
6/21/93	29.00	918	18	141	497	68	212	18	5,000	18	5,200
6/21/93	29.25	•	•	•	•	•	•	23	6,600	25	7,100
6/22/93	30.00	•	•	•	•	•	•	30	8,500	36	10,100
6/22/93	30.25	•	•	•	•	•	•	50	14,300	58	16,400
6/23/93	31.00	2,150	18	510	1,200	110	330	43	12,100	50	14,200
6/23/93	31.25	•	•	•	•	•	•	47	13,300	55	15,700
6/24/93	32.00	1,670	15	267	790	158	459	39	11,200	47	13,300
6/24/93	32.25	•	•	•	•	•	•	45	12,800	52	14,900
6/25/93	33.00	•	•	•	•	•	•	43	12,200	50	14,200
6/25/93	33.25	•	•	•	•	•	•	47	13,200	52	14,900
6/26/93	34.00	•	•	•	•	•	•	37	10,400	45	12,800
6/27/93	35.00	•	•	•	•	•	•	22	6,380	26	7,370
6/28/93	36.00	934	13	171	447	80	236	25	7,050	28	7,970
6/28/93	36.25	•	•	•	•	•	•	25	7,160	28	7,820
6/29/93	37.00	771	11	148	367	59	197	24	6,740	26	7,340
6/29/93	37.21	•	•	•	•	•	•	26	7,460	28	8,060
6/30/93	38.00	•	•	•	•	•	•	10	2,760	10	2,980
6/30/93	38.21	•	•	•	•	•	•	16	4,460	17	4,690
7/1/93	39.00	442	10	94	222	32	94	16	4,540	18	4,980
7/1/93	39.25	•	•	•	•	•	•	14	3,990	15	4,240
7/2/93	40.00	809	8	187	414	54	154	37	10,400	43	12,100
7/2/93	40.25	•	•	•	•	•	•	44	12,500	51	14,500
7/3/93	41.00	•	•	•	•	•	•	39	11,200	45	12,900
7/4/93	41.96	•	•	•	•	•	•	35	9,830	39	11,000
7/5/93	42.96	•	•	•	•	•	•	38	10,900	43	12,200
7/6/93	44.04	868	9	165	488	59	156	36	10,100	39	11,000
7/6/93	44.25	•	•	•	•	•	•	39	11,100	42	11,900
7/7/93	45.00	732	8	143	397	53	139	32	8,980	35	9,820
7/7/93	45.25	•	•	•	•	•	•	35	9,980	38	10,700
7/8/93	46.00	588	8	118	310	45	115	25	7,180	28	7,910
7/8/93	46.21	•	•	•	•	•	•	33	9,370	35	10,000
7/9/93	47.00	672	9	118	337	56	161	28	7,810	30	8,580
7/9/93	47.21	•	•	•	•	•	•	30	8,540	32	9,150
7/23/93	61.00	3,940	10	840	1,870	233	996	140	39,600	163	46,200
7/29/93	67.00	3,600	10	831	1,760	198	805	130	36,900	152	43,100
7/29/93	67.25	•	•	•	•	•	•	83	23,600	93	26,400
7/30/93	68.00	2,540	13	387	1,220	176	752	70	20,000	77	21,800
7/30/93	68.25	•	•	•	•	•	•	62	17,600	65	18,400
8/2/93	71.00	2,520	15	401	1,150	181	792	61	17,300	66	18,600
8/2/93	71.25	•	•	•	•	•	•	47	13,400	49	14,000
8/3/93	72.00	2,000	16	206	804	177	812	45	12,800	47	13,300
8/3/93	72.25	•	•	•	•	•	•	43	12,100	44	12,400
8/4/93	73.00	1,410	14	139	560	123	589	35	9,810	36	10,200
8/5/93	74.00	1,690	15	143	619	156	773	41	11,500	43	12,100
8/6/93	75.00	1,420	15	103	484	140	693	33	9,480	34	9,790
8/9/93	78.00	1,650	15	164	650	144	692	39	11,200	43	12,200
8/10/93	79.00	1,330	13	104	440	132	654	37	10,600	39	11,100
8/25/93	94.00 ****	255	11	20	76	26	133	8.1	2,290	8.8	2,490
8/27/93	96.00	853	11	81	307	77	388	28	7,960	32	8,970
8/31/93	100.00	1,290	19	128	506	112	544	23	6,670	26	7,320
9/1/93	101.00	1,500	32	102	472	137	785	17	4,730	18	5,150
9/2/93	102.00	1,240	22	83	386	115	658	20	5,550	21	6,020
9/3/93	103.00	1,050	21	83	389	95	487	18	5,120	20	5,760
9/7/93	107.00	1,320	20	102	430	121	672	23	6,520	26	7,350
9/8/93	108.00	•	•	•	•	•	•	19	5,320	21	5,940
9/10/93	110.00	895	19	59	265	86	485	17	4,790	19	5,470

Appendix F. (Continued)

Date Sampled	Elapsed Time Days	Total BTEX ppmv	BTEX % of TPH	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv	TPH* mg/L air	TPH* ppmv	HC** mg/L air	HC** ppmv
TFF-ICE-IN (Continued)											
9/14/93	114.00	1,500	25	137	512	130	723	21	6,040	24	6,780
9/15/93	114.92	•	•	•	•	•	•	17	4,760	19	5,440
9/21/93	121.00	1,240	20	100	383	116	636	22	6,160	24	6,760
9/22/93	122.00	•	•	•	•	•	•	23	6,560	26	7,420
9/23/93	122.96	921	19	75	270	91	484	17	4,740	19	5,440
9/24/93	124.00	•	•	•	•	•	•	15	4,340	17	4,940
TFF-ICE-OUT											
5/26/93	3.08	3.0	•	2.0	0.6	0.1	0.2	•	•	•	•
5/27/93	4.17	4.8	•	3.4	1.0	0.1	0.4	•	•	•	•
6/2/93	10.33	97	•	61	21	3.2	12	•	•	•	•
6/3/93	11.29	7.5	11	3.2	1.4	0.4	2.5	0.23	66	0.92	262
6/4/93	12.13	0.9	2	0.0	0.2	0.1	0.6	0.16	45	3.35	952
6/7/93	15.25	4.2	•	2.7	0.8	0.1	0.5	ND	ND	0.41	116
6/8/93	16.13	5.1	•	3.5	1.0	0.1	0.5	ND	ND	0.38	107
6/9/93	17.04	8.5	61	3.7	1.4	0.5	3.0	0.05	14	0.33	94
6/10/93	18.13	4.9	•	3.5	0.7	0.1	0.5	•	•	•	•
6/17/93	25.17	14	18	2.7	1.9	1.2	8.3	0.27	77	0.55	156
6/24/93	32.00	10	20	3.2	1.9	0.8	4.5	0.18	50	0.48	135
7/8/93	46.21	9.9	•	3.2	2.2	0.7	3.8	•	•	•	•
TFF-CFI											
5/23/93	0.00	•	•	•	•	•	•	0.10	29	0.10	29
5/31/93	8.04	•	•	•	•	•	•	0.13	37	0.14	39
6/3/93	11.25	•	•	•	•	•	•	0.05	13	0.05	13
6/7/93	15.13	•	•	•	•	•	•	0.05	15	0.06	18
6/10/93	18.08	•	•	•	•	•	•	0.07	19	0.07	20
6/14/93	22.00	•	•	•	•	•	•	ND	ND	0.04	11
6/17/93	25.00	•	•	•	•	•	•	0.04	11	0.04	12
TFF-CFO											
5/23/93	0.00	•	•	•	•	•	•	0.15	43	0.15	43
6/2/93	10.33	11	•	0.3	2.2	0.6	7.8	•	•	•	•
6/3/93	11.25	5.4	•	0.2	1.3	0.5	3.4	•	•	•	•
6/4/93	12.13	0.8	•	0.0	0.2	0.1	0.5	ND	ND	0.16	45
6/5/93	13.17	3.3	13	0.1	0.9	0.3	1.9	0.09	26	0.11	30
TFF-GSW-016											
5/5/93	*****	3,810	5	1,460	1,530	131	689	287	82,000	•	•
TFF-GEW-808											
5/5/93	*****	5,780	6	1,850	2,340	230	1,360	348	99,000	•	•

• Indicates analysis not performed.

ND: Not detected at or above limit of detection.

*Total Petroleum Hydrocarbons (Window: C6 to C12).

**Total Hydrocarbons (Window: C1 to C12).

***TFF-IOO6-VPR samples taken June 14 or later were analyzed at 80° C. Those taken prior to June 14 were analyzed at ambient temperature.

****TFF-ICE-IN sampled at 94.00 days is known to be a bad sample.

*****Sampled prior to the start of the second steam pass.

Appendix G. DUS 1st Pass PhotoVac

Date Sampled	Elapsed Time Days	Temperature °C	Total BTEX ppmv	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv
TFF-IOO6-VPR							
2/4/93	1.00	59	750	157	300	17	276
2/11/93	8.04	70	828	58	207	26	537
2/12/93	9.13	70	363	41	90	2.9	228
2/13/93	10.08	113	2,110	172	979	166	794
2/14/93	11.04	164	3,760	316	1,250	485	1,710
2/15/93	12.00	172	4,470	445	2,620	228	1,180
2/17/93	14.04	153	2,060	256	897	130	776
2/17/93	14.33	147	1,390	183	543	73	590
2/18/93	15.04	113	589	104	199	3.7	283
2/19/93	16.13	80	51	7.9	19	ND	24
2/20/93	17.04	78	87	16	25	0.4	45
2/21/93	18.08	78	904	35	87	32	751
2/22/93	19.00	84	3,200	286	608	156	2,150
2/23/93	20.08	91	513	60	170	23	260
2/24/93	21.13	104	767	82	229	27	429
2/25/93	22.04	120	1,850	123	584	146	998
2/26/93	23.25		3,170	263	1,260	228	1,420
2/27/93	24.21	141	5,980	270	1,180	625	3,900
2/28/93	25.21	149	7,220	299	1,770	818	4,330
3/1/93	26.29	155	1,410	152	618	101	537
3/2/93	27.04	158	1,680	132	861	108	583
3/3/93	28.04	161	1,390	129	758	78	422
3/4/93	29.04		1,820	103	574	158	983
3/5/93	30.33		4,510	166	1,190	379	2,780
3/8/93	33.13		959	60	326	84	489
TFF-VESI							
2/3/93	0.04	57	318	92	108	6.8	112
2/3/93	0.25	58	340	108	105	10	118
2/3/93	0.50	59	611	165	195	19	232
2/4/93	1.25	64	630	127	235	15	253
2/4/93	1.50	64	1,050	194	436	28	393
2/5/93	2.00	61	681	119	234	13	315
2/5/93	2.29	64	753	99	219	21	415
2/6/93	3.13	50	626	117	190	8.7	311
2/7/93	4.04	60	397	53	106	4.0	234
2/8/93	5.08	64	816	168	367	22	259
2/8/93	5.29	62	674	99	283	28	264
2/8/93	5.46	76	496	70	171	22	235
2/9/93	6.08		573	70	168	19	316
2/10/93	7.10	63	478	56	156	20	246
2/10/93	7.29	78	121	21	17	6.2	77
2/13/93	10.08	113	2,430	180	1,327	146	774
2/14/93	11.04	164	3,180	800	1,696	164	520

Appendix G. (Continued)

Date Sampled	Elapsed Time Days	Temperature °C	Total BTEX ppmv	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv
TFF-VESI (Continued)							
2/15/93	12.00	172	2,920	327	1,540	135	917
2/17/93	14.04	153	2,060	255	897	130	776
2/18/93	15.04	113	566	101	201	3.6	260
2/19/93	16.13	80	6.3	0.5	ND	ND	5.7
2/20/93	17.04	78	376	16	57	2.9	300
2/21/93	18.08	78	862	53	121	6.4	681
2/22/93	19.00	84	1,280	115	276	40	845
2/23/93	20.08	91	722	60	194	39	429
2/24/93	21.13	104	867	75	258	53	482
2/25/93	22.04	120	1,980	128	616	167	1,070
2/26/93	23.08	124	1,750	153	572	126	896
2/27/93	24.21	141	4,410	256	1,050	503	2,600
2/28/93	25.21	149	4,960	262	1,220	518	2,960
3/1/93	26.29	155	1,890	191	914	130	663
3/2/93	27.04	158	1,420	153	780	80	408
3/3/93	28.04	161	622	77	291	39	215
3/4/93	29.04		1,780	123	860	112	683
3/5/93	30.33		3,810	167	934	392	2,320
3/8/93	33.13		5,400	185	1,100	463	3,650
TFF-EOO6-VPR							
2/3/93	0.04	57	11	6.7	3.6	ND	0.3
2/3/93	0.25	58	35	29	4.5	0.1	1.5
2/3/93	0.50	59	14	14	0.5	ND	ND
2/4/93	1.00	59	3.9	ND	3.9	ND	ND
2/6/93	3.13	50	28	28	ND	ND	ND
2/7/93	4.04	60	ND	ND	ND	ND	ND
2/8/93	5.46	76	109	94	15	ND	ND
2/9/93	6.08		ND	ND	ND	ND	ND
2/14/93	11.04	164	499	414	86	ND	ND
2/15/93	12.00	172	296	223	73	ND	ND
2/22/93	19.00	84	ND	ND	ND	ND	ND
2/23/93	20.08	91	0.5	ND	0.5	ND	ND
2/24/93	21.13	104	7.9	7.9	ND	ND	ND
3/8/93	33.29		186	105	45	15	21
TFF-GEW-816							
2/5/93	2.29	64	756	151	288	25	292
2/10/93	7.29	78	539	66	191	35	247
2/13/93	10.08	113	2,970	306	1,730	147	790
2/16/93	13.17		3,050	418	1,470	382	780
3/5/93	30.33		2,160	152	1,100	118	795

Appendix G. (Continued)

Date Sampled	Elapsed Time Days	Temperature °C	Total BTEX ppmv	Benzene ppmv	Toluene ppmv	Ethylbenzene ppmv	Total Xylenes ppmv
TFF-GEW-016							
2/5/93	2.29	64	458	44	86	11	317
2/10/93	7.29	78	155	21	43	2.7	89
2/11/93	8.04	70	801	39	127	21	615
2/12/93	9.13	70	206	38	56	0.6	112
2/13/93	10.08	113	263	7.8	20	ND	236
2/16/93	13.17		260	24	53	7.0	176
TFF-GEW-808							
2/5/93	2.29	64	781	137	201	9.8	433
2/11/93	8.04	70	678	49	201	24	404
2/11/93	8.29		577	18	139	12	409
2/12/93	9.13	70	364	55	110	8.0	191
2/16/93	13.17		645	376	ND	269	ND
3/5/93	30.33		3,400	153	770	252	2,220
TFF-CFI							
3/1/93	26.29	155	6.5	4.1	1.4	ND	1.0
TFF-CFO							
2/3/93	0.04	57	3.5	1.2	1.5	0.1	0.6
2/3/93	0.25	58	3.3	1.9	0.8	0.1	0.5
3/1/93	26.29	155	17	5.0	7.0	ND	5.5

ND: Not detected at or above limit of detection.

Appendix H. DUS Second Pass Foxboro Organic Vapor Analyzer

Date Sampled	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv
TFF-ICE-IN			*TFF-ICE-OUT*		*TFF-CFO*	
5/24/93	1.42	140,000	1.46	42		
	1.63	260,000				
5/25/93	2.04	100,000	2.04	70		
	2.17	70,000	2.17	87		
	2.21	150,000	2.21	44		
	2.29	130,000	2.29	64		
	2.38	100,000	2.38	80		
5/26/93	3.08	80,000	3.08	70		
	3.29	100,000				
5/27/93	4.08	69,000	4.08	100		
			4.17	120		
	4.29	47,000	4.29	100		
5/28/93	5.00	24,000	5.00	120		
	5.29	30,000			5.33	ND
5/29/93	6.00	24,000	6.00	ND	6.04	0.3
5/30/93	7.00	24,000	7.00	0.2	7.00	0.8
5/31/93	8.04	27,000	8.04	0.2	8.04	1.3
					9.00	2.8
6/1/93	9.25	14,000	9.17	140	9.17	ND
6/2/93	10.08	13,000	10.08	100		
	10.17	13,000	10.17	200	10.17	0.3
6/3/93	11.00	11,000				
6/4/93	12.00	6,400	12.04	40	12.04	0.3
	12.21	7,600	12.13	104		
6/5/93	13.00	5,800	13.00	100	13.00	0.6
6/6/93	14.08	2,900	14.08	40	14.08	0.4
6/7/93	14.96	6,100	14.96	120	14.96	0.2
			15.00	20		
6/8/93	15.96	8,400	16.00	60	15.96	0.5
			16.25	40		
6/9/93	17.00	10,000	17.04	20	17.04	0.4
	17.29	12,000				
6/10/93	18.00	9,000			18.00	0.7
	18.25	9,000	18.13	80		
6/11/93	19.00	7,000	19.00	40	19.00	1.2
6/12/93	19.96	10,000	20.00	80	19.96	0.9
6/13/93	21.00	12,000	21.04	60	21.04	1.3
6/14/93	22.00	11,000	22.00	20	22.00	3
					22.17	3.1
	22.25	15,000			22.25	2.1
					22.29	1.3
6/15/93	23.00	11,000	23.13	80	23.00	1.2
	23.25	14,000			23.08	ND

Date Sampled	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv
TFF-CFI			*TFF-CFI-AFTER***	
5/24/93				
5/25/93				
5/26/93				
5/27/93				
5/28/93				
	5.33	44	5.33	24
5/29/93	6.04	41	6.04	26
5/30/93	7.00	23	7.00	15
5/31/93	8.04	26	8.04	18
	9.00	11	9.00	7
6/1/93	9.17	10	9.17	7
6/2/93				
	10.17	6.5	10.17	5
	10.25	7.3	10.25	6
6/3/93				
6/4/93	12.04	8.2	12.04	5.8
6/5/93	13.00	5.5	13.00	3.9
6/6/93	14.08	5.9	14.08	4.5
6/7/93	14.96	2.7	14.96	2.4
6/8/93	15.96	8.9	15.96	7.5
6/9/93	17.04	12	17.04	8.9
6/10/93	18.00	15	18.00	11
6/11/93	19.00	16	19.00	12
6/12/93	19.96	16	19.96	12
6/13/93	21.04	1.4	21.04	1.1
6/14/93	22.00	8.2	22.00	6
	22.17	7.2	22.17	6.2
	22.25	6.6	22.25	5.6
	22.29	12	22.29	7.3
6/15/93	23.00	5.6	23.00	4.6
	23.08	9	23.08	6.7

Appendix H. (Continued)

Date Sampled	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv
TFF-ICE-IN			*TFF-ICE-OUT*		*TFF-CFO*	
6/16/93	24.00	13,000	24.00	40	24.00	0.2
	24.25	13,000			24.25	0.4
6/17/93	25.00	13,000	25.17	60	25.00	0.3
	25.25	11,000	25.29	40		
6/18/93	26.00	7,700	26.00	60	26.00	0.3
	26.21	8,600				
6/19/93	27.00	7,800	27.00	80	27.00	0.3
6/20/93	28.00	3,600	28.00	40	28.00	0.7
6/21/93	29.00	3,300	29.00	90	29.00	1.2
	29.25	4,700	29.25	90	29.25	1.4
			29.29	60		
6/22/93	30.00	8,500	30.00	45	30.00	1.3
	30.25	13,000			30.25	1.6
6/23/93	31.00	11,000	31.00	60	31.00	1
					31.00	1.1
					31.04	1.2
					31.04	1.4
					31.13	1.7
					31.13	1.6
					31.17	1.7
	31.25	14,000			31.21	1.6
6/24/93	32.00	12,000	32.00	36	32.00	1.3
	32.25	15,000			32.25	1.4
					32.29	1
					32.29	1
6/25/93	33.00	12,000	33.00	51	33.00	0.8
					33.13	1.2
	33.25	12,000			33.25	1.4
6/26/93	34.00	11,000	34.00	60	34.00	0.8
6/27/93	35.00	5,900	35.00	60	35.00	0.7
6/28/93	36.00	6,300	36.00	54	36.00	0.7
	36.25	6,200			36.25	0.8
6/29/93	37.00	5,100	37.00	60	37.00	0.7
	37.21	5,700			37.21	0.8
6/30/93	38.00	3,400	38.00	30	38.00	0.6
	38.21	3,100			38.21	0.8
					38.29	0.8
7/1/93	39.00	4,600	39.00	30	39.00	0.8
	39.25	3,500			39.25	ND
7/2/93	40.00	9,600	40.00	60	40.00	ND
	40.25	10,000				
7/3/93	41.00	9,000	41.00	33	41.00	ND
7/4/93	41.96	10,000	41.96	27	41.96	ND
7/5/93	42.96	9,000	42.96	30	42.96	ND
7/6/93	44.04	9,600	44.04	30	44.04	ND

Date Sampled	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv
TFF-CFI			*TFF-CFI-AFTER***	
6/16/93	24.00	5.4	24.00	4.4
	24.25	5.4	24.25	4.8
6/17/93	25.00	4	25.00	3.4
6/18/93	26.00	3.9	26.00	3.3
6/19/93	27.00	4.2	27.00	2.6
6/20/93	28.00	5.7	28.00	4.6
6/21/93	29.00	7	29.00	5.2
	29.25	8.6	29.25	7.3
6/22/93	30.00	3.5	30.00	3
	30.25	4.7	30.25	4
6/23/93	31.00	16	31.00	12
	31.00	16	31.00	12
	31.04	15	31.04	13
	31.04	15	31.04	13
	31.13	1.5	31.13	1.1
	31.13	1.4	31.13	1.1
	31.17	1.4	31.17	1.1
	31.21	1	31.21	0.8
6/24/93	32.00	1	32.00	0.8
	32.25	0.9	32.25	0.7
	32.29	14	32.29	11
	32.29	1.4	32.29	1.1
6/25/93	33.00	0.9	33.00	0.7
	33.13	1.4	33.13	1.1
	33.25	1	33.25	0.9
6/26/93	34.00	0.7	34.00	0.6
6/27/93	35.00	1	35.00	0.8
6/28/93	36.00	0.7	36.00	0.6
	36.25	0.8	36.25	0.6
6/29/93	37.00	0.7	37.00	0.7
6/30/93	38.00	1	38.00	0.8
	38.21	1	38.21	0.9
	38.29	1	38.29	0.8
7/1/93	39.00	1.8	39.00	1.4
	39.25	1.7	39.25	1.2
7/2/93	40.00	1.5	40.00	1.4
7/3/93	41.00	1	41.00	0.9
7/4/93	41.96	0.8	41.96	0.6
7/5/93	42.96	0.6	42.96	0.5
7/6/93	44.04	0.7	44.04	0.5

Appendix H. (Continued)

Date Sampled	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv
TFF-ICE-IN			*TFF-ICE-OUT*		*TFF-CFO*	
7/6/93	44.25	10,000				
7/7/93	45.00	8,300	45.00	24	45.00	ND
	45.25	10,000				
7/8/93	46.00	7,400	46.00	27	46.00	ND
	46.21	8,600				
7/9/93	47.00	7,200	47.00	39	47.00	0.1
	47.21	7,300				
7/12/93	50.00				50.00	ND
7/13/93	51.00				51.00	ND
7/15/93	53.00				53.00	ND
7/16/93	54.00				54.00	ND
7/19/93	57.00				57.00	ND
7/20/93	58.00				58.00	ND
7/21/93	59.00				59.00	ND
7/22/93	60.00				60.00	ND
7/23/93	61.00				61.00	ND
	61.00	56,000				
8/2/93	70.00	25,000			70.00	0.2
	70.00	14,000				
8/3/93	71.00	15,000			71.00	0.2
	71.00	13,000				
8/4/93	72.00	13,000			72.00	0.2
8/5/93	73.00	11,000			73.00	0.2
	73.00	11,000				
8/6/93	74.00	10,000			74.00	0.2
	74.00	8,600				
8/9/93	77.00	14,000			77.00	0.2
	77.00	8,200				
8/10/93	78.00	14,000				
8/24/93	92.00	26,000				
8/25/93	93.00	2,400				
8/26/93	94.00	16,000				
8/27/93	95.00	12,000				
8/30/93	98.00	6,400				
8/31/93	99.00	7,100				
9/1/93	100.00	5,600				
9/2/93	101.00	5,000				
9/7/93	106.00	7,000				
		4,800				
9/8/93	107.00	5,400				

ND = Not detected at or above limit of detection.

*Total Hydrocarbons (Window: C1 to C∞).

**During the second steam pass the air stripping tank effluent was injected with hot dry air to reduce the moisture content of CFI samples. TFF-CFI-AFTER was taken after this addition of air.

Date Sampled	Elapsed Time Days	HC* ppmv	Elapsed Time Days	HC* ppmv
TFF-CFI			*TFF-CFI-AFTER***	
7/6/93				
7/7/93	45.00	0.8	45.00	0.6
7/8/93	46.00	0.8	46.00	0.6
7/9/93	47.00	1.4	47.00	1
7/12/93	50.00	0.7	50.00	0.5
7/13/93	51.00	1	51.00	0.9
7/15/93	53.00	2.1	53.00	1.4
7/16/93	54.00	1	54.00	0.8
7/19/93	57.00	0.8	57.00	0.5
7/20/93	58.00	0.6	58.00	0.3
7/21/93	59.00	0.4	59.00	0.3
7/22/93	60.00	0.3	60.00	0.3
7/23/93	61.00	0.4	61.00	0.3
8/2/93	70.00	1.8	70.00	1.3
8/3/93	71.00	1.3	71.00	1
8/4/93	72.00	1.1	72.00	0.9
8/5/93	73.00	1.3	73.00	1.1
8/6/93	74.00	1.4	74.00	1.2
8/9/93	77.00	1	77.00	0.9

Appendix I. DUS Wells Aqueous Data

Date Sampled	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
GEW-710							
1/15/93	80,400	45	22,000	34,000	3,770	20,600	177,000
12/16/93	174	30	23	58	13	80	579
GEW-816							
8/4/92	9,110	36	4,860	3,600	20	632	25,400
GSW-001A							
1/11/93	33,300	23	4,150	11,200	2,140	15,800	145,000
11/12/93	26,100	30	190	8,200	2,310	15,400	88,400
12/16/93	3,300	33	31	736	358	2,180	9,900
GSW-006							
1/13/93	78,600	59	34,500	32,600	1,800	9,690	133,000
GSW-007							
6/7/92	262	10	201	28	0.5	31	2,530
1/12/93	ND	0	ND	ND	ND	ND	18
5/18/93	276	10	203	45	3.3	25	2,690
11/12/93	3.2	1	1.9	0.5	ND	0.8	223
GSW-008							
1/12/93	8.1	26	8.1	ND	ND	ND	31
5/18/93	13	22	13	ND	ND	ND	58
11/12/93	ND	•	ND	ND	ND	ND	ND
GSW-009							
1/11/93	ND	0	ND	ND	ND	ND	24
5/19/93	4.6	16	4.6	ND	ND	ND	29
GSW-011							
5/19/93	15	11	15	ND	ND	ND	140
GSW-013							
1/13/93	12	2	8.9	1.1	ND	1.8	709
5/17/93	264	31	140	37	11	76	860
11/12/93	865	47	331	224	34	276	1,840
12/16/93	827	36	283	188	25	331	2,280
GSW-208							
11/12/93	16	1	16	ND	ND	0.3	2,350
12/17/93	21	1	13	3.9	1.0	3.2	2,050

1,2-DCA µg/L	TCE µg/L	EDB µg/L
218	11	122
ND	ND	ND
152	111	•
58	ND	59
ND	ND	ND
ND	ND	ND
67	ND	165
ND	11	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
1.2	31	ND
1.3	25	ND
ND	1.7	ND
ND	ND	ND
ND	ND	ND
ND	52	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
40	0.9	ND
19	4.9	ND

Appendix I. (Continued)

Date Sampled	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
GSW-215							
1/11/93	9.3	17	9.3	ND	ND	ND	55
5/20/93	12	11	12	ND	ND	ND	107
GSW-216							
1/12/93	130	8	61	66	ND	3.3	1,710
5/19/93	26,800	28	3,550	9,480	2,390	11,400	94,900
11/12/93	3,910	15	311	1,080	484	2,030	25,800
12/17/93	1,940	14	35	312	268	1,330	13,400
GSW-266							
5/19/93	ND	•	ND	ND	ND	ND	ND
GSW-326							
5/18/93	ND	•	ND	ND	ND	ND	ND
GSW-367							
5/19/93	ND	•	ND	ND	ND	ND	ND
GSW-442							
5/18/93	ND	•	ND	ND	ND	ND	ND
GSW-443							
5/18/93	ND	•	ND	ND	ND	ND	ND
GSW-444							
5/20/93	ND	•	ND	ND	ND	ND	ND
GIW-814							
1/13/93	1,560	57	977	351	38	191	2,720
11/12/93	25	27	17	2.1	1.1	4.8	91
12/16/93	1.9	10	0.3	0.4	ND	1.2	19
GIW-815							
11/12/93	753	51	36	311	68	338	1,490
12/16/93	28	25	0.6	6.7	2.3	18	111
GIW-817							
11/12/93	500	46	93	145	42	220	1,090
GIW-818							
11/12/93	617	76	139	225	40	214	809
12/16/93	261	38	47	90	19	105	678

1,2-DCA µg/L	TCE µg/L	EDB µg/L
ND	213	ND
ND	227	ND
5.3	ND	ND
ND	13	ND
1.8	1.5	ND
ND	1.4	ND
ND	55	ND
ND	ND	ND
ND	55	ND
ND	1.3	ND
ND	3.3	ND
ND	ND	ND
5.3	1.0	ND
ND	ND	ND
0.8	0.8	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND
ND	ND	ND

Appendix I. (Continued)

Date Sampled	Total BTEX µg/L	BTEX % of TPH	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	Total Xylenes µg/L	TPH* µg/L
GIW-820							
11/12/93	1,110	63	80	485	92	454	1,760
MW-510							
5/20/93	ND	•	ND	ND	ND	ND	ND
FH-416-BLRI							
1/13/93	ND	0	ND	ND	ND	ND	36

• Indicates analysis not performed.

ND: Not detected at or above limit of detection.

*Total Petroleum Hydrocarbons (Window: C6 to C12).

1,2-DCA µg/L	TCE µg/L	EDB µg/L
ND	3.1	ND
ND	ND	ND
ND	ND	2.8